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Technical Report 796

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Rapid Decision Making on the Fire Ground

Gary A. Klein, Roberta Calderwood,
and Anne Clinton-Cirotto

Klein Associates, Inc.

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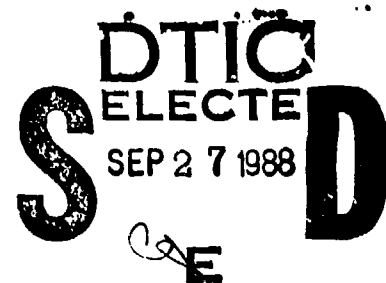
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20. Abstract (Continued)

paradigms. Interviews were conducted with 26 experienced fire fighters (mean amount of experience = 23 years). Each interview covered a critical incident that was nonroutine and demanded expertise. Most incidents had occurred within the year preceding the interview, which probed the incident decision points: options identified, options selected, and reasons for the choice. A total of 156 decision points were probed in this way. The major finding was that in less than 12% of the cases was there any evidence of simultaneous comparisons and relative evaluation of two or more options. In over 80% of the cases, the strategy was for the FGCs to use their experience to directly identify the situation as typical of a standard prototype, and to identify a course of action as typical for that prototype. In this way, the FGCs handled decision points without any need to consider more than one option. A Recognition Primed Decision (RPD) model was synthesized from these data, which emphasized the use of recognition rather than calculation or analysis for rapid decision making. (SOW)

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Rapid Decision Making on the Fire Ground

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and Anne Clinton-Cirocco**

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FOREWORD

The Systems Research Laboratory of the U.S. Army Research Institute for the Behavioral and Social Sciences supports the Army with research and development on Command, Control, Communications, and Intelligence (C³I) operations. Among a wide range of projects, research is conducted on techniques for developing automated decision aids for improving the quality and timeliness of C³I staff operations. An essential component of this research is the development and validation of objective techniques for eliciting functional knowledge and decision models from operational experts. Such knowledge, if properly obtained and codified, would provide the basis for future decision aids.

This research examined an alternative paradigm for eliciting and codifying expert knowledge in a specific functional area. It represents an alternative paradigm in the sense that it does not follow the normative decision model taught in most decision theory courses. Instead of assuming that real-world decisions are based on a rational, serial evaluation of alternative courses of action, the work adopts a pattern-recognition model for decision making under time stress. This model was tested using fire-fighting personnel from a community fire department and the basic paradigm was validated. Results of this study have been incorporated into follow-on research involving tactical C³I staff members engaged in battle management training at the Combined Arms Center, Fort Leavenworth, Kansas.



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RAPID DECISION MAKING ON THE FIRE GROUND

EXECUTIVE SUMMARY

Requirement:

The objective of this study was to examine the ways decisions are made by highly proficient personnel, under conditions of extreme time pressure, and where the consequences of the decisions could affect lives and property. The domain of firefighting was selected, and the search focused on the decisions made by Fire Ground Commanders (FGCs) who are responsible for allocating personnel and resources at the scene of a fire.

Procedure:

The method used included aspects of critical incident and protocol analysis paradigms. Interviews were conducted with 26 experienced firefighters (mean experience of 23 years). Each interview covered a critical incident that was nonroutine and that demanded expertise. Most incidents had occurred within the year preceding the interview, which probed the incident decision points: (a) options identified, (b) options selected, and (c) reasons for the choice. A total of 156 decision points were probed in this manner.

Findings:

The major finding was that in less than 12% of the cases was there any evidence of simultaneous comparisons and relative evaluation of two or more options. In over 80% of the cases, the strategy was for the FGCs to use their experience to directly identify the situation as typical of a standard prototype, and to identify a course of action as typical for that prototype. In this way, the FGCs handled decision points without any need to consider more than one option.

Utilization of Findings:

A Recognition Primed Decision (RPD) model was synthesized from these data, which emphasized the use of recognition rather than calculation or analysis for rapid decision making.

RAPID DECISION MAKING ON THE FIRE GROUND

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INTRODUCTION

Tactical and strategic decisions must frequently be made under extreme time pressure, yet current research in decision making has generally ignored the degree to which time pressure might influence the nature of decision making processes. As a means of addressing this issue, we have chosen to study the tactical decisions made at the scene of a fire by fire ground commanders (FGCs). These FGCs must allocate personnel and equipment as part of tactical planning.

It is important to define decision making within this framework. Our working definition is that decision making is the selection of one option from a set of two or more options. One question that arises is can people make a conscious and deliberate selection of one option from a set of two or more options, under constraints of a limited period of time? Or do people rely on other strategies that enable them to select courses of action without comparing the advantages or disadvantages of options?

The study of FGC decision making contrasts with traditional laboratory-based methods along a number of dimensions which illustrate the rationale of the study methods:

Time Pressure. Standard models of decision making postulate analytical processes that appear to be quite time-consuming: identifying a full range of options, specifying evaluation dimensions, estimating utilities for each option for each evaluation dimension, obtaining scores for each option and comparing these to determine the highest score. Surprisingly, there appears to be little data as to how the degree of time pressure might influence the use of decision strategies. Three applicable studies (Zakay & Wooler, 1984; Howell, 1984; Rouse, 1978) were found. In both the Zakay and Wooler study and the study by Rouse, subjects trained in decision making strategies did improve performance when conditions allowed sufficient time. However, there was no evidence that the analytic strategy improved performance where decisions had to be made under time restrictions, suggesting that degree of time pressure is an important determinant of the effectiveness of decision strategies. In two different experiments, Howell (1984) found that time pressure reduced subjects' ability to apply their own decision rules, and that time pressure combined with other variables to produce a more "intuitive" approach to problem solving, supporting the Cognitive Continuum Theory of Hammond (Hammond, Hamm, Grassia & Pearson, 1984).

Because critical decisions made at the fire ground are frequently measured in seconds, it seemed unlikely that fire ground decisions would be characterized by the consciously deliberated processes most frequently described in the decision making literature.

Expertise. Many laboratory-based studies of decision making use naive decision makers, in order to standardize the training and experience of subjects. People are asked to make decisions about something they know little about, or a problem presented in an unfamiliar way. On the other hand, FGCs are experts at making the

decisions which we are studying. Although each fire may present some unique challenge, the fire ground scene is their "home." Our expectation was that the experienced decision maker is quite different from the college sophomore who is grappling with a probability calculation or a move in a zero-sum game.

Meaningfulness of choice consequences. Most laboratory-based studies ask subjects to consider choices which have no impact on the decision maker beyond the laboratory session. At the scene of a fire, on the other hand, FGCs are making choices which affect lives and property in an emergency situation.

Paradigm. For our data gathering approach, we developed a method of retrospective process tracing based on the FGCs' memory of the fire scene and their step-by-step decisions and commands. Our interviewing approach was influenced by Flanagan's (1954) critical incident method, which has established the feasibility of using interview techniques for recreating non-routine events. Although introspective interview methods may have several weaknesses for obtaining data on mental events (Nisbett & Wilson, 1977); we felt that the possibility of capturing more of the context and phenomenological perspective of the decision maker could provide an important complement to laboratory-based descriptions.

We have characterized our data gathering approach as quasi-naturalistic. We are not attempting to be "purely naturalistic," in the sense sometimes used to designate unobtrusive field observations (Brandt, 1981). We relied on interview methods wherein our subjects knew they were being studied and knew the type of information we were trying to obtain; there was no deception involved. On the contrary, we were asking for their cooperation in reflecting on their decision making skills--a fairly "unnatural" request. The naturalistic element of our approach refers to our commitment to look at decision making embedded in as much of its natural context as possible.

In summary, we selected fire ground decision making because it was a naturalistic task, with highly time-pressured decisions which are made by highly experienced FGCs, within a variety of contexts. Our primary goal was to gather descriptive data on the way decisions are made. We see a need for descriptive models which are aimed at clarifying issues arising in the areas of training, selection, and decision support.

METHOD

Approach

In the preliminary phases of this research effort, a semi-structured interview technique was developed for this study, loosely based on Flanagan's (1954) critical incident methods.

Adequacy of memory for the critical incidents. Studies using Flanagan's (1954) critical incident methods have generally supported the feasibility of using post-interview techniques to obtain event descriptions. The general finding is that non-routine events in the work place are reported more accurately and completely than more routine events. In preliminary interviews with fire chiefs we found that the most challenging incidents in an officer's career were remembered quite well. In terms of level of detail and the vividness of their accounts, this seemed to be the case for incidents occurring even 5 to 10 years ago.

The availability of decision making processes to consciousness. Quite apart from the issues relating to adequate memory for the event is the question of whether introspection is a valid means of collecting data about mental processes.

Although we believe that introspection is a legitimate source of data, we do not presume that it offers a direct access to cognitive processes. It is an indirect measure with its own peculiar biases and limitations. Its attractiveness is that it offers a potentially rich source of hypotheses. The firefighters' ideas about how they make command decisions stand on their own as an important source of data. The ultimate validity in relation to any proposed cognitive model will be judged by the usual standards of scientific acceptability.

The biases of reconstructive memory. To what extent were the methods we used gathering valid descriptions, and to what extent were the subjects simply telling us what they perceived we wanted to hear? We obviously cannot determine this absolutely, but we developed a number of techniques designed to improve the accuracy and consistency of the interview data. These techniques which will be described in the section on the Interview Guide development. Our general strategy was to focus our probes in the direction of obtaining rule-based, rational calculation and option deliberation descriptions. Only when we could not obtain such a description did we probe for alternative descriptions.

Subjects

A total of ten fire departments were contacted with seven departments agreeing to participate in the study, although one limited the degree of its cooperation. Three cities declined to participate.

The level of cooperation and scheduling procedures varied from department to department. Some departments allowed us to contact any of their officers directly to schedule an interview; others picked certain officers we could speak to. In all cases, we attempted to

schedule a preliminary interview with the department chief or assistant chief, to familiarize him with the study and to learn about the department's structure and procedures.

In addition to allowing interviews, most departments that we contacted agreed to let us ride along on fire calls and observe the fire incident. We found our few experiences as ride-alongs to be helpful in getting a feel for fire ground operations. However, we decided early in the study that these observations were not providing sufficient data to justify the expense of having observers on call for these rare events.

Material

The Interview Guide was developed in an attempt to strike a balance between two disparate elicitation objectives. On the one hand, we wished the interview to be as unstructured and as free from interviewer bias as possible, so that the details of the fire command would emerge with the officer's own perspective and emphasis intact. On the other hand, we did not want simply a collection of unrelated fire stories. Our perspective required that we direct the officer to focus on those elements of the incident which most affected his decision making and to structure these answers in a way that allowed the incidents to be summarized along specified dimensions.

Our solution to these conflicting goals was to ask the officer to describe the incident completely, from beginning to end, before we began our questioning. This procedure was judged to be quite successful, in part because it seemed to establish the interviewer as a listener rather than as an interrogator, and in this sense increased cooperation. After the incident had been related, the interviewer then clarified and probed each event on the interview timeline. The officer's account may have jumped around in relating the events and decision/commands. The timeline focused on representing the actual sequencing and duration of events, as well as the information and cues available at each decision point. This technique was effective for clarifying the incident events and resolving questions and inconsistencies. An additional purpose was to reactivate as much of the context of the scene by asking the officer to recount the events from different time perspectives, a technique which has demonstrated utility in obtaining accurate eyewitness testimony (Geiselman, Fisher, MacKinnon & Holland, 1985). The decision probes went through a number of refinements during the preliminary data collection phase and can be seen in the copy of the Interview Guide included in Appendix A.

Data Summary Techniques

Incident Accounts. The first step in the analysis was to reconstruct the account of the incident, attempting to capture in as rich a detail as possible the incident scene from the point of view of the commanding officer. Notes and timelines were checked against the complete taped interview. These accounts are included in Appendix B.

Decision Point Structure. Using the completed Timeline and Incident Account, each incident was then structured into the decision format which forms the basis of the analysis.

A decision point was defined as a point in time when alternative decisions or courses of action could have been chosen or taken. Thus, for each decision point there was a chosen option and one or more alternative options. An important point to be made is that this part of the analysis was largely inferential. One of the first things we learned is that the officers rarely saw themselves as either generating or selecting from a set of alternatives. We had to probe to identify options that did exist at each decision point. The FGCs experienced themselves as acting in a manner prescribed by their knowledge, perceptual cues, and goals at that moment. Thus, it was important to try to elucidate the knowledge, perspective, and cues (which we have termed "situational awareness") as they were operating and shifting throughout the incident.

The complete analysis of the decision points attempted to document the nature and chronology of the officer's situational awareness and each (non-trivial) decision point obtained from the Incident Account. Each decision point was characterized along a number of dimensions.

1. What other options were actually (or hypothetically) available to the decision maker?
2. How was the chosen option selected?
 - was it a deliberated choice?
 - could a selection rule be articulated or inferred?
3. How much time was taken in making the decision?
4. How much time pressure was involved in making the decision?
5. What level of experience was required to make the decision?
 - how much experience was required to interpret the cues or know which cues to look for?
 - was there a rule that could be implemented by a less experienced officer?
 - what kinds of critical knowledge or cues were found to be missing?

Answers to the questions were sometimes available as answers to specific probes during the interviews. At other times we had to infer answers to these questions based on our understanding of the incident, and departmental and fireground procedures. For example, an officer may have indicated that he called a second alarm because "all of the available manpower and equipment was being utilized," which is an explicit fire ground procedure and did not require further explanation. However, in a case where the officer suspected roof collapse and ordered his men to evacuate, the decision was based on subtle and complex cues. The rule, "If the roof is about to collapse,

then get out" is obviously not very helpful. The expertise is in knowing when this situation warrants a decision. This type of decision must be probed for the interviewer to capture the decision maker's situational awareness.

Questions about time and degree of time pressure were difficult for FGCs to estimate. In many cases the answer to the time probe was simply "immediately," or "I just did it automatically, based on experience." These expressions were coded as less than a minute, although in verifying this with the subjects many indicated that it was actually less than thirty seconds. Time pressure was also difficult for the officers to report, so it was largely inferred on the basis of the timeline information.

Quality control procedures

Early in the course of conducting interviews, we found that it was difficult for one person to capture all of the relevant aspects of the interview, including obtaining and probing a complete timeline. It was therefore decided that it was preferable for two interviewers to be present. However, for seven of the interviews there was only one interviewer present. Also, because interviews were generally 2 hours long, it was decided to tape each interview so that later discrepancies and questions might be resolved.

Coding was a lengthy process, requiring anywhere from 3-7 hours per incident. Because of the number of incidents we wished to obtain, it was not feasible to implement any formal procedures for obtaining an assessment of inter-coder reliability. The following informal quality control procedures were employed: 1) each Incident Account and Decision Analysis was read and criticized by the other member of the interview team or by one of the interviewers; and 2) each Incident Account and Decision Analysis was then reread and questioned by each of the two principal investigators (who also may have been a member of the interview team).

RESULTS

Incident Characteristics

We collected 32 separate critical incidents. These were the bases for all data analysis. They were collected from a total of 29 interviews which were conducted with 26 officers. In three cases, the same officer was interviewed twice concerning different incidents. In two other cases, multiple incidents were recounted in a single interview session because the officer's account of the initially selected incident was extremely short, yielding only a few decisions. One fire, at an oil pumping station, was so large that it was counted as three separate incidents (roughly covering three separate days of the incident) and was recounted by two different officers. Two incidents are separate versions of the same fire given by officers of different rank, offering different perspectives. Of the 32 incidents, 29 were fires, 2 were rescue operations, and 1 was a gas leak.

The officers interviewed were of high rank and experience, including lieutenants (6), captains (4) and chiefs (16). The 26 officers had an average of 23.2 years of firefighting experience. None of the interviewees had less than 12 years of experience, and the maximum was 37 years.

The interviewees also had command experience. For twenty-eight incidents, the interviewee was the FGC initially in charge at the scene. The other four incidents involved officers in charge of squadrons or sectors.

The criterion for selecting a particular incident was that it presented a command challenge or was non-routine in some way. We found that the officers' reasons for selecting an incident could be characterized by four factors. Any of the factors which applied were checked for each incident: 14 were designated as recent incidents, 13 were unusually high risk, 5 contained disappointments in terms of the outcome, and 12 were designated as primarily non-routine.

In general, the selection of incidents did provide us with a good range of cases for study. There were rescues, fires in single residences, apartment houses, hotels, businesses and factories, an oil tank truck, and a large complex of oil tanks. We were concerned with the experienced FGCs' decision process and not the correctness of the decisions. In some cases we found errors in judgment, and in the case of the oil pumping station, the situation was so unique and complex that the FGC had little experience in handling the situation and eventually needed to bring in consultants for guidance. A few of the incidents were selected because they involved dramatic search and rescue operations. These were vivid for the firefighters, but tended to be less interesting from a decision-making perspective.

The incidents selected generally occurred within the year prior to the interview. Table 1 shows the frequency distribution of the incident recency. The median is less than one year, and this is the mode as well. More than a third of the incidents had occurred less

TABLE 1
Frequency Distribution of Incidents' Recency
Prior to the Interview

<u>Time Prior to Interview</u>	<u>f</u>
Less than 1 month	6
1- 3 months	5
3- 6 months	1
6 months- 1 year	7
1- 3 years	2
3- 5 years	7
More than 5 years	<u>4</u>
TOTAL	32

than three months prior to the interview. Four of the incidents had occurred more than five years earlier.

Officers were also asked to rate the incident on four separate risk factors: the risk to the initially burning structure; the risk to the adjoining structures or property; the risk to civilian life; and the risk to firefighters' lives. Ratings used a 3-point scale with 1 indicating low risk, 2 medium risk, and 3 high risk. All the incidents were classified as high risk on at least one dimension. The mean ratings for the 28 unique incidents were 2.7 for risk to the involved structures, 1.6 for the risk to adjoining property, 2.2 for the risk to civilian life, and 2.6 for risk to firefighters' lives.

Containment is a point at which the fire is no longer escalating, not including the final fire control operations or salvage. The median reported time to contain a fire was 2 hours. The shortest fires were contained in 15 minutes, and the longest lasted 12 hours, with the exception of the pumping station fire which took one week to contain.

The total alarms called for a fire gives a rough estimate of the seriousness; although procedures vary widely from department to department. Seven of the incidents were 1-alarm calls, 6 were 2-alarms, 8 were 3-alarms, and 2 were 4-alarms.

Analysis of Decision Points

The basic unit of analysis in this study was the decision point, the point in time where multiple options existed.

For the 32 incidents studied, we analyzed a total of 156 decision points, with an average of 5 decision points per incident. The number of decision points ranged from 1 to 10 per incident.

Time. Table 2 shows the FGCs' estimated time in deciding on a course of action at each decision point. As expected, the decisions were generally very time-critical; the large majority were reported to have been made in less than one minute, with many of these being made in under 30 seconds. Because of the difficulty of estimating these short time durations from memory, we have categorized all of the shortest decision times as simply being under one minute, and 78% of the decision points fell into this category. Many of the remaining decisions were still made in a short time: approximately 10% in under 2 minutes and another 6% in over 2 minutes but still under 5 minutes.

TABLE 2

Frequency Distribution of Estimated Time
(in minutes) for each Decision Point
(Pumping Station Incident Data in Parentheses)

<u>Time</u>	<u>f</u>	<u>Total</u>
< 1	116 (16)	132
1 - 2	14 (1)	15
2 - 5	4 (6)	10
> 5	<u>9</u> 134 (22)	<u>9</u> 156

Virtually all of the longer decisions are from incidents #30-32, a pumping station fire. This was a unique case in our interviews. First, it took almost a week to contain, which is an order of magnitude longer than even the longest of our other cases; and second, the local firefighters who tried to contain the blazes could not be considered experts. The scope of the fire and the problems encountered were unique in their experience. In addition, there were problems in coordinating the efforts of the several departments involved, so there was initially no clearly designated FGC. Thus, in the pumping station fire, many of the decisions were made in consultation and were stretched out over several hours. Because the three pumping station incidents so clearly represent a different command and control situation from our other incidents, the data for these incidents are

indicated separately in the time categories summarized in Table 2.

Time Pressure . Table 3 shows the degree of time pressure we judged was experienced by the FGC. This is conceptually distinct from how rapidly the decision was made. For example, a decision might be made very rapidly simply because it can be, not because it must be. Conversely, there may be a great deal of pressure to make a decision rapidly, but the actual decision making process may have been carried out more slowly. We simply rated each decision point for its degree of time pressure using a 4-point scale; where 1 = low time pressure (incident stable); 2 = some potential for escalation; 3 = imminent loss of control, and 4 = threatened loss of life. As can be seen in Table 3, a majority of the total decisions were made under conditions of some extreme urgency; 61% of the decisions were ranked as either time pressure levels 3 and 4. For these levels, every second was important for combatting the exponential increase in the fire. Another 36% fell into urgency level 2, in which perhaps minutes were available for making the decision. Only 3% were made under low time pressure. All but two of these decisions were from the long-term pumping station incidents.

TABLE 3

Frequency Distribution of Estimated Time Pressure
for each Decision Point
(Pumping Station Incident Data in Parentheses)

<u>Time Pressure</u>	<u>f</u>	<u>Total</u>
1 (low)	2 (3)	5
2	40 (16)	56
3	55 (1)	56
4 (high)	37 (2)	39
	<hr/>	<hr/>
	134 (22)	156

Decision Type. One of the most important goals of this study was to describe how the officers reported making their decisions. We had originally expected that the FGCs would tell us about the decisions that they had trouble making. This rarely happened. In almost no case did a FGC even report making a decision, in terms of comparing two or more options and trying to select one. In other words, we found virtually no instances of the standard laboratory paradigm for decision making: conscious and deliberate selection of one alternative from several.

We tried several coding schemes to describe the way that the FGC handled each decision point. Table 4 shows the number and type of decision strategy found for each the 156 decision points.

TABLE 4

Frequency Distribution of Decision
Strategy used for Each Decision Point
(Pumping Station Data in Parentheses)

<u>Type</u>	<u>Frequency</u>
Option Selection	0
Deliberated	10 (8)
Constructed	7 (4)
Procedural Rule	0
Analog	3
Prototype	114 (10)
Total	134 (22)

One category which was considered was Option Selection, whereby the FGC would receive the options from an external source and select one. This category describes a standard way that decision making is studied in laboratories. However, we saw no evidence that any of the FGCs used this approach. In fact, we found only a very small subset of decisions where alternative options were even considered, let alone concurrently contrasted. For ten of our decision points, not including the pumping station incidents, we found that the FGCs consciously contrasted options in arriving at a decision (Deliberated). In these cases, the FGC would typically identify two or more ways of accomplishing a goal, and then would make the selection on the basis of a single, or only a few, dimensions, such as

the time required and risk factor involved. There was never any systematic examination of all the relevant attributes, in an attempt to perform a rudimentary decision analysis.

Another type of decision was when the FGC faced an unfamiliar situation and had to creatively generate or construct the possible options (Constructed). There were 11 cases that fell into this category.

In the case of the pumping station, roughly 59% of the decisions were arrived at through a consciously deliberated process, almost always in group consultation. Therefore, the deliberation component may apply to the group aspects of the decisions being made, more than to decision making for any individual.

The majority of the decisions were characterized, not by option consideration, but by the FGCs recognizing the situation as an example of something they had encountered many times before. In other words, there was evidence for a matching process, rather than a calculational process.

The first type of matching we looked for was matching to a specific analog -- another situation they had been through or heard about. We found very few cases of this. We specifically probed for analogs, and found only three. There were no cases where one fire was treated as an analog for another. Rather, the analogs seemed to serve as flags, which alerted the firefighter to dynamics of the situation that needed attention. Their effect was on situational awareness, and on specific decision points. In Case # 5, for example, the FGC looked up at a billboard near the roof of an apartment building that was burning down, and remembered another time when a billboard had collapsed, falling off the roof and posing a hazard to firefighters and civilian onlookers. He therefore ordered the crowds to be moved back.

Apparently, the FGCs had so many similar firefighting experiences that these became merged in memory, with no specific cases standing out. A fire could be spoken of as typical, which suggested our next category: a Prototype. For example, they have been through hundreds of house fires. When they encounter one, they view it as typical of their prototype, which would include some standard layouts, some standard approaches, and so on. We are using prototype in a way that overlaps the concepts of scripts and frames, and we will discuss the theoretical issues further in the Discussion section. Nevertheless, it is important to clarify how we are using this category. The FGCs encounter a decision point; they recognize a match to a prototype, and the prototypical scenario guided by experience tells them how to proceed. In this way, they implement a course of action without ever considering any of the other options at the decision point. In our interviews, we probed this very carefully, and the FGCs were clear that they were not aware of other options. That is why they did not feel that they were making decisions.

To ensure that these were really decision points, we probed to identify potential options. Usually, the subjects were not able to

find any. In these cases, we asked about options that a novice might be foolish enough to consider. Sometimes we had to suggest the options. As long as we found at least two options, we considered it a decision point. We did not study how many such options existed, since we were now dealing with the hypothetical.

For the 156 decision points, 127 fell into the Prototype category. This was the dominant approach. Options were selected without any reports of conscious examination, evaluation, or analysis. In most cases, the events triggered an immediate recognition of what to do, and the action was taken. However, there were three decision points where there was not a match but a lack of a match, and this mismatch triggered a new situational awareness and the reassessment or shift to another plan. In Case #4, a firefighter led his men into a burning house, found the apparent seat of the fire in the rear of the house, and directed a stream of water on it. The water did not have the effect expected, so he backed off, then hit it again. At the same time, he began to notice that it was getting intensely hot and very quiet. He stated that he had no idea what was going on, but he suddenly ordered his crew to evacuate the house. Within a minute after they evacuated, the floor collapsed. It turned out that the real fire had been in the basement. He had never expected this. This was why his stream of water was ineffective, and it was why the house could become hot and quiet at the same time. He attributed his decision to a "sixth sense." We would be less poetic and infer that the mismatch was the cue. The pattern of cues deviated from the prototypical patterns where heat, sound, and water are correlated.

Another category we tried to use was a Procedural Rule. In this case, there would be a rule of the form: If x, then do y. All the FGC would have to do is match the x condition, in order to determine whether to implement the y action. In practice, we had difficulty in distinguishing this from matching to a prototype. In both cases, there is a matching, followed by an action. The only difference is that the rule is context-free, whereas the prototype is context-rich. We were not able to find any examples of context-free rules that could safely be initiated by complete novices. If the concept of a procedural rule is broadened to include contextual sensitivity, then the border between procedural rule and prototype matching becomes very blurred.

Table 5 is a summary of decision time and time pressure findings for each decision type. It simply confirms the tendency for Deliberated and Constructed decisions to be made under less time pressure and to take longer to make than decisions made on the basis of a prototype match/mismatch.

TABLE 5

Frequency Distribution of Decision Types, Time, and Time Pressure
(Pumping Station Data in Parentheses)

TYPE	N	TIME				1	PRESSURE			
		<1	1-2	2-5	>5		2	3	4	
Prototype	117(10)	108(6)	7	2(2)	0(2)	2(1)	33(7)	47	35(2)	
Deliberated	10 (8)	5	4(1)	1(2)	0(5)	0(1)	5(7)	5	0	
Constructed	7 (4)	3	3	1(2)	0(2)	0(1)	2(2)	3(1)	2	
TOTAL	156(22)									

Situational Awareness

Because we treated decision making as a form of complex pattern matching, much of the expertise of the FGCs came through in the situational awareness. This reflected their understanding of the dynamics of the case, and was the basis for their ability to recognize cases as examples of standard prototypes. In many of the cases, the initial situational awareness was maintained throughout the incident, with new information serving to elaborate on what was originally known.

In other cases, there were dramatic shifts in the situational awareness. For example, Case #23, a fire at a chemical plant, the situational awareness included the dynamics of a burning structure and flowing chemicals, as well as the risk of nearby storage tanks exploding. Foam is the first choice for putting out a chemical fire; it extinguishes the fire by smothering it. However, the tanks required cooling to reduce the risk of explosion, and water is the best coolant. A novice may have used foam initially to try to extinguish the fire; or used both water and foam, which would have produced a diluted and ineffective foam.

The expert's decision was to use water initially to cool the tanks, then shut down the water and apply foam. He used his perceptual ability to judge when the tanks had been appropriately cooled, so that an explosion was no longer likely. He relied on such cues as heat waves and steam levels coming off the tanks. When the foam operation was begun it was monitored and judged effective. Later, however, runoff was discovered to have been seeping into the basement of an adjoining structure, creating a new fire hazard. The situational awareness was now changed, and the FGC recognized a new out-of-control situation. He immediately called for additional manpower and equipment to handle the expanded situation. This example

shows the perceptual ability needed, the ability to rapidly assess the situation, the ability to shift this awareness, and the ease of making decisions.

In our data analysis we decided not to define a change in situational awareness every time anything happened or failed to happen. This would have become cumbersome. We reserved our changes for those items where there was a shift in goals or subgoals as a result of new information. For most incidents, there were generally 3-5 different situational awareness changes. Rarely did we identify more than 10.

In our coding for situational awareness we developed a checklist of nine dimensions that seemed useful. These are presented in Table 6. The exact number of dimensions or the ones selected are not important here. What is important is that these dimensions reflected different classes of causal factors that were being learned and interpreted by the FGCs to suggest and constrain courses of action.

In determining how situational awareness was growing, we had to infer what expertise was needed to interpret new facts and to perceive changes. The elaboration of the required expertise took the form of a knowledge analysis, or a critical cue analysis. It described the type of knowledge and recognitional ability that the FGCs needed to handle these critical incidents. As such, it was quite different from the standard firefighting procedures offered as guidance for fighting fires. Instead of vague statements about how the FGC needs to be able to determine when water is hitting the seat of a fire, we have specific cases such as #21, where the FGC thought he was getting at the seat of the fire, waited for signs of white smoke that show a fire is being extinguished, found none after about 30 seconds, and began to worry that he did not know where the seat of the fire was at all. This type of description defines the cue, the nature of the cue changes being assessed, and the time frame for expected cue changes.

TABLE 6
Situational Awareness Cue Checklist

1. PROBLEM
 - a. Smoke - color, amount, toxicity
 - b. Fire - amount, location
 - c. Explosion potential
 - d. Chemicals
 - e. Rate of Change
 2. STRUCTURE
 - a. Type - factory, house, office, vehicle, etc.
 - b. Materials - wood, brick
 - c. Architecture - special features
 - d. Age
 3. PROBLEM x STRUCTURE
 - a. Seat of fire
 - b. Possibilities for movement
 4. WEATHER
 - a. Temperature
 - b. Moisture
 - c. Wind - velocity, direction
 5. RISK TO LIFE
 - a. Direct cues
 - b. Knowledge of potential risk
 - c. Special populations (elderly, disabled, etc.)
 6. RISK TO FIREFIGHTERS
 7. NATURE OF ATTACK
 - a. Progress
 - b. Hindrances
 8. RESOURCES
 - a. What is available?
 - b. What is needed?
 - c. Special needs
 9. GOALS ASSESSMENT
 - a. Search and Rescue
 - b. Fire Control
 - c. Property Conservation
-

DISCUSSION

The study was successful in challenging some of our basic assumptions about decision making and forcing us to re-conceptualize our approach. In this section, we will discuss several aspects of that re-conceptualization: (a) a Recognition-Primed Decision model; (b) a characterization of situational awareness; (c) methods for describing perceptual learning; (d) related processes such as analogical reasoning and imagery; and (e) types of deliberated decision making. Finally, we will discuss the accomplishment of the project objectives, and some of the implications of this research for issues such as decision aids and the selection and training of decision makers.

Theoretical Issues

(a) Recognition-Primed Decisions. The major finding of this study was that FGCs rarely report having considered more than one option. In an analysis of 156 decision points, we found that in only 28 was more than one option even identified. In only 16 did the FGC report doing any relative evaluation of one option vs. another, and these are for cases specifically selected for their difficulty. If there were instances where they would have had to wrestle with choices, it would have been these cases. We therefore concluded that the standard approaches to decision making would not apply to the vast majority of these cases.

Their ability to handle decision points appeared to depend on their skill at recognizing situations as typical, as instances of general prototypes that they had developed through experience. The prototypes provided them with an understanding of the causal dynamics at work, suggested promising courses of action, and provided them with expectations.

By contrasting concurrent with serial models of option evaluation, the FGCs' decision making strategy can be more accurately described. Figure 1a shows a standard decision analytical structure, with the options down the side and the evaluation dimensions across the top. In such a model, the decision maker is presumed to consider several options at the same time; perhaps performing pair-wise comparisons, and to make concurrent, conscious judgments and relative evaluations of the strengths and weaknesses of the different options.

In contrast, Figure 1b shows a serial option evaluation model. Here, an option is generated, and then either implemented or rejected. If rejected, a second option is considered, and so forth. This may be described as a serial model of decision making, because although one or more options are considered, only one option is examined at a time. We feel that this model is a better fit for the data we collected.

FIGURE 1

Models of Option Evaluation

Figure 1(a)

1(a) Concurrent Evaluation - Vertical Model

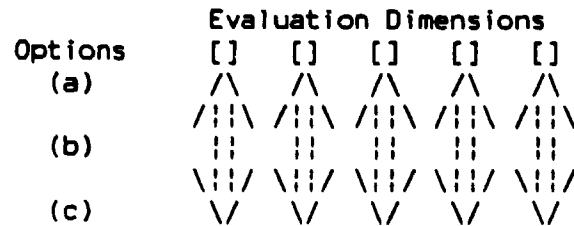
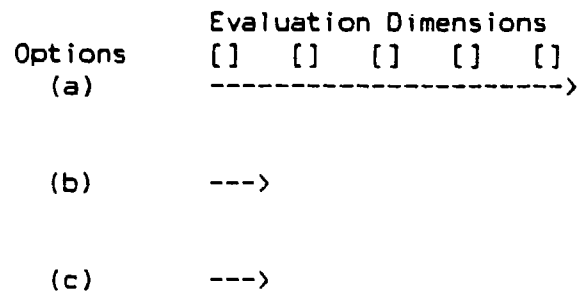


Figure 1(b)

1(b) Sequential Evaluation -Horizontal Model



We were specifically studying decision making under extreme time pressure, where there is a need for rapid decisions. We therefore characterize our description as a Recognition-Primed Decision (RPD) model.

We have developed a different approach to decision making in part because of the way we conducted this study. We looked at decisions made under extreme time pressure performed by personnel with high levels of experience and personal commitment. The use of the quasi-naturalistic design has given us a unique perspective.

Standard laboratory studies usually do not use highly experienced subjects. These studies tend to focus on the analytical skills needed to evaluate options, and they leave option generation as something of a mystery. Campbell (1960) described this sort of approach as random generation and selective retention: basically a random generation of options, followed by analytical methods to identify and select the best option.

For our subjects, option generation fell out of their situational awareness. They were able to identify good options immediately -- this was part of their skill. Von Clausewitz (1943) has referred to this ability as coup d'oeil, the skill in making a quick assessment of a situation and its requirements. In contrast to Campbell, we are placing more of the burden on the recognitional processes and the use of experience to generate a plausible option as the first one considered.

For a time-limited task, concurrent evaluation is probably impossible. It takes a lot of time to consider all options along all evaluation dimensions. Even reducing the number of options and dimensions still places an unreasonable load on the decision maker. Serial evaluation seems necessary. Decision researchers may have to study situational awareness and expertise to understand how effective options are immediately recognized.

The advantage of a RPD model is that it provides the decision maker with a course of action at every point. The decision maker begins with an initial option, and if a response is called for, this will be executed. If there is time for some evaluation, it will be examined, accepted, improved, or rejected for a second option which then becomes primed for implementation. In the situation we studied, it is critical that the decision maker always be ready to act effectively.

The RPD model may explain some aspects of intuitive decision making (Hammond et al., 1984). If subjects are using recognitional and perceptual matching processes, it would be understandable that they could not articulate the bases for the decisions. Our RPD model is also consistent with Simon's (1955) notion of satisficing. Simon introduced the concept of satisficing to point out that decision makers typically do not do all the work to ensure optimal decisions. He was criticizing the economic assumption of rational man. However, he did not offer an explanation for how satisficing could be accomplished. How can people be sure of finding workable options without generating all options possible and evaluating these?

Several approaches to serial evaluation models have been proposed. A lexicographic method (e.g., Aumann, 1964; MacCrimmon, 1968) postulates that a decision maker generates a set of options, orders the evaluation dimensions, starts with the most important, and selects the option that has the highest rank on the most important dimension. If there is no clear winner, the second dimension is examined, and so on. This model allows serial evaluation, but still concurrent consideration of options, and does not fit the majority of our data.

A second model is Tversky's (1972) elimination by aspects. Here, several options are generated, they are evaluated on the first dimension, any that do not pass a criterion are rejected, the remainder are evaluated on the second dimension, and so on. Again, this is concurrent consideration of options and serial evaluation on dimensions. This model does not fit our data because it stops when one option is left remaining. This could still take a long time, and

it is unrealistic since an option might still be unacceptable on remaining dimensions. Finally, it does not allow the generation of new options without starting the whole process over. Clearly, this will not do for a time-pressured task.

A third model is that of conjunctive standards (Bettman, 1971; Kleinmuntz, 1968). Here, there are criteria for each evaluation dimension. One option is generated, and if it fails to meet any of the criteria it is rejected and a second option is evaluated. This is a better description of the data we collected. But there are still a few shortcomings. This model lacks a description of how effective options can be generated immediately, something we will discuss below. More important, our analyses suggested that options are not evaluated as systematically as in a model of conjunctive standards. We did not see FGCs carefully examining any option to see if it passed the criterion point on several dimensions. Rather, there was a general matching of the current situation to the prototype. If the match was good, then the option was implemented. If it was questionable because of differences in causal dynamics, then the FGC began to consciously evaluate, often by imagining how the option would be carried out and what difficulties might arise. In some cases, the option could be augmented to handle the difficulties. In other cases, it had to be rejected. This approach is basically the one described by de Groot (1978) who studied the way grandmaster chess players would select a favorite option, and explore its adequacy through progressive deepening. The grandmasters were not looking at all options and conducting shallow evaluations (the way a computer program usually does).

An example might be helpful. In Incident Account #9 there was a call to rescue a semi-conscious woman who had jumped off a highway overpass, and was dangling suspended on one of the metal supports for a sign. The FGC rushed to the scene. Two of his crew had climbed onto the supports and were holding her arms and legs. In that situation, the immediate need was to provide a firm basis of support for her. The standard approach is to use a Kingsley harness, which snaps onto a victim quickly and allows the victim to be moved and raised. However, the woman's position was not standard, since she was face down, and a Kingsley harness is strapped on from the front. He imagined moving her into position, and realized this would place her and his crew in danger. He also felt that attaching it from the back, a non-standard approach, would create severe strains on her back. (Tests the next day showed he was right.) He rejected this option. Next, he considered another standard type of rescue equipment, a Howd strap. This loops onto a victim in different ways. But again, the match wasn't right. Howd straps are also attached from the front, and are open to the same weaknesses as the Kingsley harness. He rejected this option. Next, he thought about ways to use the Howd strap differently, but could not come up with any strategies simple enough to guide his crew through. Finally, he remembered the ladder belt, which firefighters strap around their waists and clip to their ladders to make sure they will not fall off during a rescue. Ladder belts can easily be attached from the back, and have only one buckle. Moreover, a simple rope could be used to attach the ladder belt to the crew above her. He quickly ordered the ladder belt brought out. This

decision took less than one minute from the time he first arrived at the overpass. Once the ladder belt was on her, he then attempted to rig up a Howd strap to her arms and chest, to make it easier to raise her up.

This example shows how the FGC examined four options, all serially. The standard method was considered, evaluated, and rejected; another standard method was considered, evaluated and rejected. Next, an attempt was made to construct one option, and then when this seemed unlikely; a second constructed option was identified, one that had never been used before in that type of situation. There was never any attempt to compare two options at the same time.

The example also has an interesting postscript. A hook and ladder truck had been sent below to block traffic and had raised a ladder to assist in the rescue. While the original rescue crew was fumbling with the Howd strap, the woman started to roll off the bar, and the ladder crew below said they were ready to catch her. The FGC therefore ordered that she be guided down, using the ladder belt. However, the woman was slender, and "limp as a strand of spaghetti." Ladder belts are made for sturdy firefighters, to fit over their protective coats. The woman simply slipped through the belt and fell. Fortunately she fell into the arms of the hook and ladder crew below, and the rescue was made. Was there a better option? Yes, a very simple one--to use the rope, tie it onto her wrists, and secure and perhaps raise her that way. The option was never considered. It was not available in the FGC's awareness. Ropes are no longer considered prime rescue tools. Only afterwards did the FGC realize what he should have done.

This incident also suggests that the prototypes used by the FGCs may include action queues.¹ That is, there was a dominant response (The Kingsley Harness) and when this was rejected there was an immediate backup (a Howd Strap). The other options were novel, but the first two indicate that prototypes must include an ordered set of response strategies.

(b) Situational Awareness. In the RPD model of time-pressured decision making, situational awareness becomes very important. We are claiming that most decision points can be handled without deliberation by applying an "if x...then y" strategy. The key to making this work is that an effective option be immediately identified in the majority of cases. And the way that experienced FGCs can identify effective options is to match the current situation to a prototype, thereby recognizing it as typical and amenable to typical procedures.

The recognition of a situation as typical of a prototype depends on the way the FGC has assessed the scene and its problems. That is, the ability to know that "x applies" is dependent on situational awareness. The situational awareness provides the information for triggering the conditional.

¹ We are indebted to Robert Holt for this observation.

For example, a simple procedural rule would be "if the firefighters are in danger, remove them from the scene." This makes a lot of sense. It is also useless, unless you are able to determine that the firefighters are in danger. That is why we do not feel that we are dealing with context-free rules that can be supplied to novices to make them experts. The FGC must have the perceptual and cognitive ability to make fine discriminations and to understand causal implications. For example in Case #12, a simple residential fire, the FGC sent a crew into the building with a hose to hit the seat of the fire. The rule might have been "if there is a fire in a house, hit the seat of it." It is a standard procedure, apparently requiring little expertise. However upon probing we found that another procedure might have been to send the hose around the house, break some windows, and hit the fire from the back. This might even have been faster. The FGC never considered it. The basic idea is not only to hit the seat of the fire, but also to drive it out of the house. Hitting the fire from the back would only drive it further into the house. Continuing our probing, we asked if anyone would have sent the hoses around back. The FGC said that this was done too often by people who should know better, trying to reduce the risks to their crews. It might be appropriate if there was no one in the house, or if the house was not worth saving, or if there were adjoining structures that could be endangered by an internal strategy. All of a sudden, a simple decision became complicated.

To illustrate how situational awareness affects perceptions and decisions, and how it can shift, consider Case #7, a call about a suspected fire in the basement of an apartment building. The FGC suspected a trash fire on the way over, and in walking past the front of the building he saw no sign of smoke in any of the windows or the front outside stairwell. Should he continue the size-up or evacuate the building? What would you choose?

He never considered evacuation, but proceeded to the rear of the right side, went down into the basement, and found that the laundry chute was enveloped in flames that were spreading up past the ceiling of the basement. Should he continue his size-up, call in hoses to hit the fire at the basement, hit the fire at a higher floor, or evacuate the building? What would you choose?

Here he has a rule: with a fire that is being directed up a vertical path by the construction of the building, hit it from above. There was no reason for him to continue walking around the building, and he did not consider evacuating the building since it seemed that the fire was containable. There was no reason to hit the fire in the basement since it was spreading upwards and already had reached the first floor. His assessment that the fire was containable made his choice obvious--to send a hose to the second floor. He subsequently found that the fire had moved beyond the third floor, and in re-inspecting the building he saw smoke coming out of the eaves in the front of the building. At this point he could send hoses to the fourth floor, call a second alarm, or evacuate the building with the crew available. What would you do?

His assessment was that the fire was no longer containable without great risk to the occupants. He visualized how the fire must have spread up the laundry chute to the fourth floor, hit the ceiling there, and spread down the hall towards the front of the building. His dominant goal shifted from extinguishing the fire to performing search and rescue. His immediate reaction was to call in a second alarm, to provide the additional manpower he would need. The new crews would be assigned the task of search and rescue on the fourth floor (where the fire was primarily spreading) and keeping the front stairway clear. Earlier, the front stairway had little significance. The shift in situational awareness changed the strategy and the significance of the stairs. The FGC chose this fire to describe because of how the situation had shifted so abruptly.

Part of the skill of an FGC is in knowing when to obtain more information. The term they use is "size-up." Theoretically a size-up must be done at every incident prior to acting. However, for practical reasons, it is not always possible to complete the size-up. Valuable time can be lost continuing a size-up while a fire spreads out of control. For example, in Case #26, a fire in a factory, the FGC began to walk around the factory, saw a fire burning through the wall, and immediately ordered his crew to train their hoses on it. He recognized that it was a good place to use his resources and did not want to let it burn further while he kept walking. His experience allowed him to judge what a good place to hit a fire looked like. A novice would not be able to make such a judgement. In another situation, Case #14, a fire in a lower basement of a restaurant, the FGC chose to go down into the basement to size-up the fire before ordering hose lines. He felt he could do this size-up more quickly without bringing along a hose crew. However once he found the fire, he had to find his way back, run up several flights of stairs, get the hose crew and guide them all the way back. Precious time was lost. In this domain, time is critical and actions must be initiated without the benefit of complete information analyses.

(c) Perceptual Learning. The FGCs showed an impressive variety of perceptual learning. For example Case #21, a fire in a plastics factory, required that the FGC interpret the smoke color, the color of the fire and the sponginess of the roof to assess the situation. At first, there was only smoke coming out of the front of a factory. The FGC assessed this as a simple fire, and trained his hoses on the source of the smoke. If he were hitting the seat of the fire, the smoke should have turned whiteish within 30-60 seconds. It did not, and he concluded that the fire was burning further inside. He sent some firefighters to the roof, to open a channel that would let the heat and smoke escape. They reported that the roof in a back section of the factory felt spongy. He went up to investigate, since to inexperienced personnel all roofs can feel spongy. He found that the roof indeed had a spongy feel, and ordered his men off of it. He concluded that the fire was larger than he had thought, and was probably burning directly below them. There is no way to describe what a spongy roof feels like. This recognition comes only with experience of walking on roofs that are solid and roofs that are spongy, and learning to discriminate between them. Finally, they found the seat of the fire. Its bright orange color suggested that

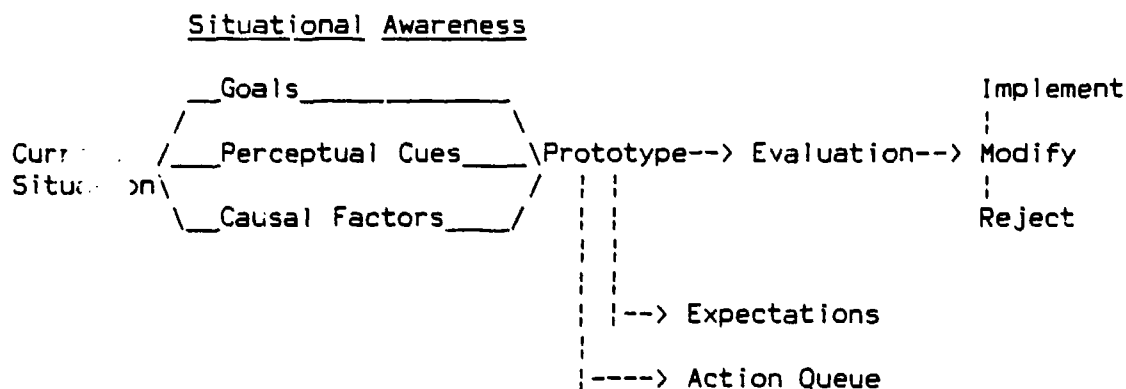
the heat was in excess of 1000 degrees F., and a second alarm was called in.

The interview guide approach that we used highlighted the perceptual cues used by the FGCs, and our coding system retained this information by linking these critical cues to situational awareness and to RPDs. Therefore, our approach may be useful for developing a critical cue inventory of the types of cue discriminations that must be maintained for expert performance. It may have value as a knowledge elicitation method that would feature perceptual knowledge rather than rule-based knowledge.

The RPD model is summarized in Figure 2. The current situation matches a prototype, based on similarity of goals, perceptual cues at the scene of the fire and causal factors and information about these. The prototype generates expectancies and also a set of options, with the most typical option generated first. The action is evaluated for plausibility and is implemented, modified or rejected. Often if there is an unfamiliar situation the evaluation will include imagery for the anticipated consequences of using that option. If the option is rejected, the next most available and representative and similar is selected for evaluation.

FIGURE 2

RECOGNITION-PRIMED DECISION MODEL



(d) Related Phenomena. There were several phenomena that were found during this study that may be of interest. One was the use of imagery. In evaluating options, a common strategy was for the FGC to create an image of how the option would be implemented. This strategy was used rather than the analytical method of evaluating the option with regard to criteria on several dimensions. An example is Case #10, a rescue of an injured and unconscious motorist from an automobile that had crashed. The commander was in charge of a rescue squad. Upon arrival he noticed that the supports for the roof were severed, suggesting that the car had rolled over. The driver was trapped inside. None of the doors were functional. Firefighters were yelling

for him to get the "jaws of life," a hydraulic device for prying apart metal. This in fact was the standard operating procedure. However he hesitated. He had once discussed the possibility of just lifting a victim out of a car. He realized that all he had to do was push the roof off to get at the victim. He spent a few seconds imagining how he would move the victim, at what angle, where he would use a sled to support the victim's back, how he would turn the victim, etc. In the image, the rescue seemed to work. He tried it at least a second time, and it still worked. So he ordered his crew to carry it out with his guidance, and was successful.

A second phenomenon of interest was the failure to find evidence of analogical reasoning. We had originally expected to find a great deal of analogical reasoning. We found little. The reason is probably that with increasing numbers of similar experiences, analogs become less vivid and fade out altogether, becoming prototypes. We would expect that for less experienced personnel, analogs are still important. Where we did find analogs, they were to specific cues and features of a situation, especially nonstandard ones.

It should also be noted that we are using prototype here to refer to syntheses of analogs. We are not claiming that episodic memory has transformed into semantic memory (Tulving, 1972), since this would involve the degeneration of context-rich episodes into context-poor semantic networks of abstract elements. We think this is wrong, since the FGCs were still very sensitive to contexts, especially as it alerted them to features of situations that had potential implications. The way we are using prototypes includes a highlighting of the general features of situations along with a potential for specific details where relevant.

A third phenomenon is the reliance on constructed options--cases where the "if x" portion of the RPD has been satisfied and the means of implementing the "then y" portion needs to be found. Usually there is a standard means, but sometimes the FGC will need to find a unique means, or will reject the standard approach in favor of an innovative one, as in the car rescue example above. This is important because decision making models must be able to describe how subjects can synthesize options to develop new and improved options. If decision making is treated entirely as a way of selecting between a fixed set of options, then the opportunity for growing new options will be missed.

(e) Types of Deliberated Decision Making. Although most of the decision points were best described by a RPD model, there were about 10% (not including the pumping station incidents) that included some sort of conscious processing for selecting one option from several that were considered.

To understand the nature of this deliberation, several typical examples will be described. In Case #28, the FGC felt that he had lost a chance to contain a fire and had to select which of the adjoining buildings to try to save. He picked the newer buildings on a side which seemed at highest risk. In Case #3 The FGC had to decide how to send a firefighter up into an attic. The stairs had burned

down, and he could either use the stringers (the remaining portion of the stairway) or bring in a hand ladder. He picked the hand ladder as the safer option. In Case #19 the FGC was afraid that a gas leak would create fires in nearby houses. He came to one that was empty and deliberated about whether to break in or go to another house to find the owners or find a key. He decided not to break in because he was sensitive to the public's image of firefighters as "ax-wielding morons." In Case #27, a FGC was relieved of command when a higher ranking officer arrived. He was given an order that he believed to be wrong, and had to deliberate about whether to obey. In Case #29 the FGC had to decide which pumper to send where; the decision was made on the basis of his knowledge about which would arrive first. In Case #15, the FGC was just finishing the clean up of one fire when the call of another came in; he had to decide whether his crew was fresh enough to send out on the new call.

In none of these cases did the FGC attempt to identify additional options. The focus was on the primary options that were identified. In none of these cases did the FGC go through an exhaustive evaluation of relative advantages and disadvantages on each important evaluation dimension. Once the FGC was confident that each option was worth considering, the decision was reported to be made on the basis of a single over-riding dimension, such as safety or time savings.

One fire does stand out as a contrast to our general findings, and this was the subject of three interviews, Cases #30, #31 and #32. It was a fire at a pumping station. The station pumped oil and natural gas from the south to various points in the midwest. The complex included huge tanks for holding the oil and gas. In the middle of the winter, with a wind chill factor of -40 degrees F., one of these tanks ruptured, and the oil ignited, creating a wall of flames over 50 feet high. The scene was a rural setting, and the arriving firefighters had never experienced anything like this before. The entire town was built over pipes running from this complex, and the potential for disaster was great; yet there was no apparent way to attack the fire. There was no water at the site, there was very little foam, there were few roads for bringing in engines. At certain points it seemed that the other tanks seemed to be ready to explode or ignite. Although a ladder went up the side of each tank, climbing was judged to be extremely dangerous. The first attempt to spray foam at a rim failed because of the distance at which the trucks had to be placed, as well as the high winds.

The command structure and experience at this fire were unlike our other incidents. Fire companies from six small towns were called in, and somehow had to be coordinated on the spot. The cold forced most firefighters to wear masks for warmth, which disrupted the chain of command since the FGC was not easily identified. Basically, the fire chiefs were reduced to the level of novices since they were working with something outside their usual experience. They had no prototypes for action, and they did not take many actions. They stumbled around for two days trying to figure out what to do. The actions they did take were the subject of fierce deliberations. They decided to take the third day off, just to plan. In all, the fire took seven days to contain, and success was largely due to their decision to bring in

consultants who did have experience with fires of this magnitude, and who were immediately able to see what was needed and what courses of action to take. Prior to that, as the FGC put it, "our heads were like stone." The pattern of their decision making does conform more closely to the standard accounts. They consciously worked to identify options. They were unsure about the advantages and disadvantages of options, and had to try to figure these out analytically since they did not know what to expect.

(f) Organizational Issues. We encountered several issues that may be of interest for Army analyses of Command and Control.

One potential weakness of FGCs is that they persist in combatting fires too long. They are oriented towards extinguishing the fire, and are therefore reluctant to give up, even when giving up that goal is appropriate. In Case #17, a fire in a first-floor restaurant of a downtown highrise, quickly spread to endanger the entire building. The FGC recognized the futility of trying to extinguish the fire, and shifted his resources to stopping the fire at alleys which provided natural lines of defense. This meant giving up that building, along with several others. A subordinate firefighter was in sharp disagreement, and wanted to continue fighting the original fire. The FGC felt that this aggressive spirit, while helpful in some situations, would have left the entire downtown block exposed and endangered. The initial allocation had to be effective; it was very difficult to shift resources once they are committed.

Another issue was the distribution of command responsibilities. Firefighters generally have large amounts of experience, and FGCs learn that they can rely on the judgment of the captains and lieutenants, and do not try to directly control all activities. For example, in Case #5 the FGC ordered crews into a burning apartment too dangerous and that the crews were retreating, he accepted their judgment. He did not question them or attempt to perform his own size-up. He was confident that they would have continued if possible. Case #21 was an exception. The FGC arrived at the scene of an apparently straightforward fire in a small factory. He did not know that there was a much larger wing of the factory behind the 2-story section he saw. The captain on the roof reported that the fire was getting out of hand in this back section, and that the roof was becoming dangerous. The captain was not used to working with this particular FGC, and felt that his report was not given the credibility awareness. The captain had to depart from usual procedures, climb down from the roof and repeat his report "face to face" with the FGC to force him to reconsider.

A third issue is the acceptance by FGCs that their role is supervision rather than direct action. In Case #27 the FGC got caught up in the urgency of a rescue and went into the building that was burning. The lack of supervision on the outside meant that communications were reduced, placement of equipment was poor, and the entire effort appeared to suffer. In Case #22 the FGC did leave the search and rescue efforts to his crews even though an angry crowd was

urging him to help out with the rescue of children. He effectively directed the arriving crews and coordinated a smooth attack on the fire. This issue of supervision vs. intervention may be specific to firefighters' command structure where all officers have also been firefighters and only gradually assume command responsibilities.

Accomplishment of Objectives

The majority of objectives were accomplished, although several were accomplished in ways that had not been anticipated.

One objective was to develop a new type of knowledge elicitation approach that highlighted perceptual learning and recognition matching processes. This was accomplished, as described in the Methods section. It took a number of iterations of the interview guide and the interview procedures, and we will probably revise further in light of what we have learned from the data analyses. Nevertheless we did develop a tool for eliciting more subtle aspects of expertise.

Second, we intended to assess the value of a heuristic model of decision making. This was accomplished, but the model we were assessing was found to be inadequate. We had hypothesized that FGCs did not have time to consider a wide variety of options, and we speculated that they would use a strategy of considering only two options at a time, for purposes of direct comparison. We thought that this was a radical hypothesis. In fact, it turned out to be too conservative. In general, they only considered one option at a time, as described by the RPD model.

Third, we wanted to increase our understanding of decision making by experts under high time stress. We were partially successful in this. We have proposed a descriptive model, the RPD model, and we have a better appreciation for the role of situational awareness. Yet we realize that there is still much to learn. In hindsight, our estimates of time to make a decision was overly focused on the time to choose the option or course of action. Our time estimates do not include the time to make the situational awareness, which in many cases is the most important aspect of the decision.

One concern that we had was for the validity of our findings. Verbal protocols as a data source have a long history in psychology, but have at various times been dismissed as an invalid variant of introspection. Nisbett and Wilson (1977) most recently attacked verbal protocol methods on the basis of laboratory studies in which subjects apparently had little conscious awareness of the effects of certain stimuli on their responses. However, several researchers (Ericsson & Simon, 1980; Smith & Miller, 1978; White, 1980) have refuted the strong version of Nisbett and Wilson's claims. Ericsson and Simon cite evidence that they feel directly supports the validity of verbal protocol data. Other refutation arguments focus on specific aspects of Nisbett and Wilson's methods which encouraged subjects to speculate in a general fashion about their motivations for behaviors, rather than refer to their actual memory for the event. In short, although Nisbett and Wilson have demonstrated that subjects do not always accurately report information related to higher cognitive

processes, it is not necessarily the case that they never do.

In our study, we tried to avoid the tendency for subjects to speculate by asking subjects to recreate as much as possible what they were actually seeing, hearing and thinking at a specific moment. We never simply asked "why" an action was taken, which is a procedure Nisbett and Wilson have been criticized for. Furthermore, we suspect that asking experienced personnel to reconstruct aspects of their decision processes is different from asking subjects to speculate on their motivations in an unfamiliar laboratory environment. In our case, even when our probes directed officers to consider possible options which they might have considered, the FGCs firmly insisted that this was not what they actually did. Thus, although their recall may still be inaccurate, it was not likely due to acquiescence to experimenter bias. Regardless, we do not present our data as firm evidence supporting our model. Rather, we are suggesting that the retrospective protocols enabled us to generate new hypotheses, a procedure which is recommended in semantically-rich domains (Newell & Simon, 1972).

We were also concerned that our critical incidents may not have been typical, but we do not feel that this is a problem. Each incident included approximately 5 decision points that were probed, and many of these were routine. In addition, the use of critical incidents would have over-emphasized the difficult and deliberated decisions, not the prototype matches.

Applied Issues

The RPD model of decision making under time stress has potential implications for the selection, training and support of decision makers. The model suggests that it will be useless to require decision makers to make comparative evaluations of several options. This is a time-consuming process. Instead, decision makers must rely on their experience and ability to quickly recognize the causal dynamics of situations as a way of generating effective options and evaluating these.

With regard to selection, there may be individual differences in the way people feel comfortable relying on recognitional matching as opposed to more analytical processes. If these differences could be established and validated, it may help assign individuals to conditions where analytical evaluations are necessary versus those where analytical evaluations are not possible.

With regard to training, it may be valuable to reconsider the worth of teaching people to generate and evaluate a variety of options, if they are going to be placed in situations where this will be counterproductive. Instead, it may be more efficient for training programs to be reconceptualized to emphasize the perceptual learning needed to make fine discriminations, the array of experiences needed to develop situational awareness skills and to acquire a repertoire of options. We will need to perform additional research into the dynamics of situational awareness in order to develop more definite guidelines for training programs.

Finally, the RPD model suggests that it would be a mistake to develop decision aids only along the lines of decision analytical theories. In time pressured situations, people will not be able to perform the operations needed to make comparative judgments. It would be much more valuable to make sure that decision support systems are providing an effective situational awareness. We hypothesize that decision supports that provide options will not be used, or will lead to degraded performance under time pressure, whereas decision supports for situational awareness will improve performance. This hypothesis may interact with cognitive styles, and with the experience level of personnel, but it should be considered prior to the development of support systems for personnel who will be required to make time-pressured decisions.

Summary

In conclusion, this effort was extremely valuable for the opportunity to learn about decision making under time pressure. We had expected to study how options are chosen from among alternatives, and instead we found that comparative option selection does not often occur. We wanted to study analogical reasoning, and instead we found little evidence for the direct use of analogs.

For these reasons, we were forced to develop a new understanding of decision making, as presented in the RPD model, whereby effective options are directly generated and evaluated for adequacy without any comparisons to other options. This model links decision making to pattern matching, perceptual learning, and the formation of prototypes in memory. It asserts that decision behavior can no longer be appreciated in isolation from these other aspects of psychological functioning.

Future research is needed into the knowledge elicitation tools we used and into the postulates of the RPD model--use and nature of prototypes, aspects of situational awareness, existence of action queues, conscious analysis of one option at a time, and evaluation of options.

It is hoped that the elaboration of the RPD model will provide a means for increasing the applicability of decision research for operational problems and requirements.

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APPENDIX A: INTERVIEW GUIDE

FIREGROUND DECISION INTERVIEW GUIDE AND DATA RECORD

Department: _____ Interview date: _____

Conducted by: _____

Transcribed by: _____

Interview time/transcription time (in man hours) _____

I. INTRODUCTION

Describe purpose of the study — learn about how experts such as command level fire officers make decisions under extreme time stress. Klein Associates (small industrial psychology company established in 1978). Interview will focus on decisions made at fires which were demanding from a command perspective. Approximately 2 hours to conduct interview.

II. BIOGRAPHICAL DATA

Name/rank:

Firefighting Experience (years, where, positions held, approx. dates):

Optional remarks (special training, job satisfaction, etc.):

III. INCIDENT DATA

A. Choice of Critical Incident

The incident may have been preselected as recent incident of interest. If not, officer should choose most recent incident which presented a challenge. In general, the more serious the incident, the more likely it will be that command, rather than procedure will play an important role. Any factors which make the incident exceptional in some way should be considered, such as risk to life, non-standard operations which were employed, mistakes which were made, etc. Errors in judgment may be particularly informative.

Note why incident was selected:

____ Recent ____ High risk ____ Disappointment ____ Non-routine

____ Other _____

B. Officer's Incident Account

Officer is asked to relate all the events from the time the alarm was received, focussing on his commands and critical decisions. This part of the interview should be unstructured to allow the perspective of the officer to emerge. Probes on decision making and timeline details should be carefully timed so as to interfere as little as with important points the officer wishes to make.

C. Probing for Specific Information

1. Timeline details. Because we are so interested in how time pressure affects decision making, we wish to gather as much information as possible as to the sequencing and duration of events occurring at the fireground. The timeline also functions to clarify and even aid the officer in recalling the incident. If this is difficult for the officer, stress that relative time information is more important than clock time. It may be possible to check certain details against supporting documents (some incidents are reported in timeline form as part of the incident report).

2. Decision/Command Probes

In general we are interested in finding out all that we can about how a fire ground commander makes decisions on the fire ground, including critical decisions which were faced, options considered at each decision point (why one was chosen, others rejected), strategies employed, critical information available and lacking, etc. During the interview, the interviewer will identify and probe key decisions which were made at the scene.

The Timeline can serve as a partial checklist for the type of information which wish to have for each key command/decision. Additional probes are more or less relevant or important depending on the nature of the incident and the type of information revealed in the incident account. A number of probes for the type of information considered central to this study are listed on the next page. Although this list can serve as a checklist, it is best for the interviewer to be thoroughly familiar with these probes and to judge when they are most appropriate.

KEY COMMAND/DECISIONS

Keylabel

GOAL	What was the decision/command objective?
INFO/SOURCE	What information relevant to the decision was available and how was it obtained?
INFO/CONF	How confident was officer of information (low, med, high)?
OPTIONS	What other options were considered?
BASIS	How was this option selected? (What rule was being followed? If no rule, probe for use of analogy, scenario, etc.
CONSCIOUS	How conscious was officer of making decision?
CRIT EXP	What specific training or experience was necessary to make this decision? (at what point in his career would the officer <u>not</u> have had the requisite knowledge to make a good decision).
MISTAKE	How might a less experienced officer have behaved differently? (Where are mistakes most likely?)
HELP	If decision was not the best, what training or knowledge or information was missing which could have aided the decision?
TIME PRESSURE	How much time pressure was involved in making this decision (scale 1-4)? 1=very low, as low as ever experienced in an incident 4=very high, as high as ever experienced in an incident
TIME	Estimate how long was taken in actually making the decision

INCIDENT PROBES

ANALOGY	Pick the most similar/helpful case. Describe differences.
SCENARIO	Does the incident fit a standard scenario that you have ever seen or been trained for? (Probe basis for match, differences/modifications)
#INCIDENTS	How many incidents like this have you been involved in? overall _____ at a command level _____
STRATEGY	What were the overall strategies employed (offensive/defensive during course of incident?

CODING ABBREVIATIONS

Information

D = direct visual/auditory/smell
R = reconnaissance
P = preknowledge
Disp = dispatch
FF = other fire fighter
C = citizen report
Unk = if an event or piece of information was unknown at the time of its occurrence. On data record, note when the information became available

Strategy objectives

S/R = Search/rescue
FC = Fire control
PC = property conservation

Specific Goal

SZ = sizeup
M = manpower
E = equipment
Evacuation
Safety
Speed
Planning

Degree of Consciousness

Automatic
Some reflection
Conscious consideration of alternatives

General Abbreviations

FF = fire fighter
FG = fire ground
FGC = fire ground commander
EMS = emergency medical service
EMT = emergency medical technician

INCIDENT CHECKLIST

Date of incident _____ Location _____

Type of structure _____

Number of Alarms _____ Time of Day _____

Weather conditions _____ Time to Containment _____

Casualties _____ Est. property loss _____

Cause? _____

Officer's command level at fireground _____

Judged risk factors (low, med, high)

Structure _____	Adjoining property _____
Civilian life _____	FF endangerment _____

TIME	CRITICAL MOMENTS	INFO	COMMAND/DECISION	BASIS	STRAOAL S T R A O A L G	Risks COMMENTS (OPTIONS, TIME, CONSCIOUSNESS)

A-6

APPENDIX B: INCIDENT ACCOUNTS

INCIDENT ACCOUNT #1

TANKER TRUCK

This incident occurred 18 months ago. The incident involved an overturned tanker truck on fire. It had been carrying a full load of jet fuel, on an access ramp of an interstate highway during morning rush hour. The Chief had never been involved with a tanker fire before and this fire was particularly hazardous because of the existence of another tanker approximately fifty feet behind the overturned one.

Chief McW heard the dispatcher call sometime during the city's morning rush hours. Instantly recognizing the location as being within his area, he headed out in his car toward the area given by the original dispatcher call. The only information given by the dispatcher was that a tractor trailer was involved. On his way to the scene, the Chief saw a huge column of black smoke coming from the freeway at a location that was not the area of the original report. The location of the box alarm was some distance from the incident. The Chief acted on the visual cue of the smoke and arrived at an expressway off-ramp of a major interstate within two minutes of the call. Getting closer to the scene, the Chief saw a column of flame and citizens running from the scene, abandoning their cars. On his arrival he saw a tanker truck laying on its side, ruptured lengthwise, and engulfed in flame. "I immediately breathed a sigh of relief, because the danger of explosion was less than if it (the truck) was split in half," the Chief noted. A second tanker was about fifty feet from the overturned one. At the same time as this quick size-up, the Chief started toward a group of citizens who were helping the injured driver of the crashed vehicle away from the immediate area. While assisting in this evacuation, the Chief questioned the driver about his load and found that the tanker was carrying JP-4 jet fuel and had just been fully loaded. About thirty seconds had elapsed from the Chief's arrival.

The Chief then got on his radio and 1) corrected the address given by the original dispatcher call, 2) called for a rescue unit for the injured driver, 3) requested police action to stop the flow of traffic, and 4) called for a special firefighter unit that dispensed foam. By the time the call was completed, the first alarm units had arrived and were attempting to hook up to the nearest hydrant located some distance from the scene. A five inch hose was going to be used from this source - a size that would drain the reservoir carried on an engine in about a minute. A smaller size hose was connected to the engine and was directed toward setting up a stream of water around the wrecked tanker; the hydrant supply was not available for about 15 minutes after the units had arrived. The Chief directed the streams to be set up for the protection of the firefighters and would not allow his men to advance on the fire until the protective streams were in place. He saw that the fire was well underway and pretty intense, but burning straight up and not threatening to expand much. The danger was that the saddle tanks of the tanker or other pockets of fuel would explode. A ladder truck was also directed to extend its ladder pipe and aim a water stream down on the scene. While this was

being accomplished the Chief sent the driver of the first fire truck on the scene down the ramp to check for occupants in the abandoned cars.

Two foam units then arrived, one at each end of the damaged tanker. The Chief coordinated their foam-dispensing operations so that the streams were at acute angles to each other. At this point the Chief felt that the situation was pretty much under control - but then a storm sewer behind him "blew," i.e. exploded into flame. He realized that burning fuel was now in the sewer system and recognized that this new aspect of the situation would exceed his span of control. He called for another alarm to be given. The next Chief arriving with these new units was tasked with removing the danger from the sewers while Chief McW left his attentions on the tanker.

The total time to containment was more than an hour. Chief McW was at the end of his shift during the mop-up phase of the tanker operations and decided to go home when all that remained was to right the truck.

INCIDENT ACCOUNT #2

BACKDRAFT

The incident took place two months prior to the interview and was of interest because of 1) the spread and size of fire involved; 2) a backdraft explosion that caused firefighter injuries, and 3) the FGC was only a Captain with a year in grade, but was acting District Chief at the time.

The alarm call came in at 0950 hours on a Sunday morning in May. Capt. N, acting District Chief, arrived at the scene in about one minute. When he was three blocks from the scene he saw large amounts of black smoke and flames at a building he knew to be occupied as a renovated 4-story multi-family dwelling. The Captain knew then another alarm would need to be called. He pulled his car past the building to allow the alarm equipment to arrive and, as he was stepping on to the street, he scanned the windows for life and the location of the fire. Now citizens were exiting the building's front doors and the Captain was getting reports of trapped citizens still on the third floor. He quickly continued to scan the smoke line of the front of the building, seeing smoke forced from the eaves of the roof and much more smoke and flames from the rear of the building. Then he called a code 3 alarm (special equipment) to get an additional engine and a rescue squad.

Continuing his size-up, the Captain made his way to the rear of the building. The fire could be seen to involve the 2nd and 3rd floors but was progressing rapidly, jumping from eave to eave on the 4th floor. This markedly quick advancement convinced him he didn't have the manpower at the scene to fight and that a second alarm was necessary. Quickly noting the exposures as he completed a circuit of the building, Capt. N came back to the north end or front.

The involved building was seen to have two priority exposures: the south end, where an adjacent building abutted against it, and the east side where the structure crowded the sidewalk and posed a threat to the buildings across the street.

This appraisal gave the Captain the information he needed to place his equipment. However, he first had to pull a ladder crew from the north end roof, where they had automatically begun to set up ventilation operations to perform search and rescue of the 3rd floor rear area of the building. This action was against the Captain's conceived operational fire plan but was made urgent by the persistence of a woman from the involved building who had continued to trail the Captain, insisting that a woman known to her was still trapped on the 3rd floor. Dispatching this crew, the Captain radioed for a second alarm to be given. Only six minutes had elapsed since the first alarm, and only three since the code 3 was called.

Although he had realized that a second alarm was necessary much earlier, the captain had somewhat delayed the second alarm call on his experience that the first alarm and code 3 units would need a little time to set-up. The confusion of too many units arriving and

attempting to set up operations was what he wanted to avoid.

The arriving second alarm units were radio-directed to their positions by the Captain. He had prefigured their placement before their arrival, committing the second alarm engine heavy rescue and ladder companies to search and rescue in the back with the one first alarm ladder company. He then turned over responsibility for the back operations to the second alarm District Chief. The other first alarm ladder company had been tasked with knocking out the 3rd and 4th floor windows in the front. Before allowing both the first and second alarm companies inside the building, Capt. N made clear he wanted quick radio communication on the nature of the fire when they encountered it.

No other staff officers had arrived at this time and the Captain maintained overall FGC responsibility as he stationed himself in the front to oversee the north and east sides of the building. He became concerned when several minutes had elapsed after the dispatched crews had entered the building but no white smoke (water turning to steam) could be seen. This indicated that the firefighters had not yet made contact with the fire and this delay was distressing because of the rapid progress the fire had made since the fire companies arrival. A radio report then came in from the firefighters inside that steel safety doors were obstructing attempts to enter the 3rd floor. The delay in getting the information to Capt. N had occurred because the firefighters had, on their own initiative, gone to obtain the necessary equipment to open the doors and were in the process of that operation.

Monitoring the situation, he saw that a crowd of 15-20 people had gathered in the front to watch the fun. They posed a danger to themselves and to firefighter operations; and in the interest of safety, Capt. N shepherded them across the street. As this action was completed a large explosion was heard -- a backdraft had occurred. Fearing immediately that the building was coming down, he ran about fifty feet up the street without pausing to ascertain the nature of the event. Capt. N then turned back to see a firefighter enveloped in flames on the 3rd floor jump out of the building to an aerial ladder positioned near there. Trapped firefighters on the burning 3rd floor were now yelling to be evacuated.

The explosion had occurred on the 2nd floor, blowing out all the windows, including those that had remained on the 3rd and 4th floors after the ventilation crews had been through. Shards of glass littered the street where shortly before a crowd of naive, gawking bystanders had gathered. The potential civilian casualties could have been extensive had Capt. N not cleared the scene.

Coming only eight minutes after the second alarm, Capt. N immediately radioed a third alarm with the information that firefighters were trapped. He feared that some firefighters had been killed and others badly injured. He specifically ordered extra rescue units to the scene. Capt. N ordered all internal building operations discontinued and all crews inside to evacuate. The Captain wanted a head count to assess his casualties and was conducting one when the

Assistant Fire Chief responding to the third alarm arrived. Capt. N. gave a report of the situation as he knew it at that time, emphasizing that not everyone (firefighters or civilians) could be accounted for yet and that a fourth alarm was probably necessary. The arriving Chief now assumed overall FGC responsibility, with the Captain taking charge of the front and east side operations. A fourth alarm was called ten minutes after the third; a completed head check had revealed no firefighter deaths but six injuries.

The fire companies regrouped and then resumed internal building operations. Fire containment occurred within two hours of the first alarm and the entire incident was judged successfully handled. A training film has been made of the operations at this site as captured by the media coverage.

INCIDENT ACCOUNT #3

5-GLITCH FIRE

This was an 8 month old incident chosen because, "It seemed like everything that could go wrong, did go wrong".

The single alarm call came in at 2108 hours to a residential address. Chief M. immediately thought of several things associated with this neighborhood. Many of the houses were large, old houses which had been refurbished and made into apartments. He thought of the need for rescue, many of the residents were older, retired people. He considered all of this on the way to the scene.

Within approximately three minutes, the Chief arrived at the scene and began his sizeup. The involved structure was a very large, refurbished mansion which had been converted to a 3-family dwelling. He saw a lot of bright orange flame coming from the 1st floor west-side bay window, indicating that the fire was very hot (1200+ degrees) and was receiving enough ventilation so that it would burn quickly. He knew he had to get water on this fire quickly, or it would get away. He ordered a 1 3/4" line taken through the front door for an aggressive direct attack.

As hose lines were being laid, someone came out of the building to say that someone was still inside in the vicinity of the burning room. Chief M ordered the first arriving truck company to gain access and rescue the trapped victim. Unfortunately, the truck crew could not gain access until the fire had been knocked down, and fire control was to be delayed. Immediately after Chief M heard the nozzleman order "start the water" he heard the reply, "We're not getting it". The hydrant was malfunctioning and another pumper had to be set up to relay water to the first engine before water could be applied (Glitch #1). Given the malfunction, Chief M knew he would need help, and called a second alarm (at 2112).

By the time access was gained, the fire was already spreading to the 2nd floor. (When the victim was found he was already dead, although a subsequent investigation determined that he had been dead even before the firefighters arrived on the scene.) Chief M and his crew worked feverishly to extinguish the fire on the 1st floor and had worked their way up to the 2nd when they received a report that a person was calling for help from the 2nd floor balcony (at 2118). Chief M had to redeploy two companies currently fighting the fire to get ladders up and rescue this person. Thus, an already minimal manpower situation (two companies were at three man minimum staffing already) became more critical when these companies had to be redeployed to rescue (Glitch #2). The fire would certainly get away now.

By the time the ladders were up and the victim was rescued, the second alarm companies had arrived and were assigned to inside fire attack and to outside ventilation, which was needed desperately on the roof to keep the fire from spreading horizontally through the structure. Unfortunately, the house was set so far back from the

street that aerial ladders could not be used (Glitch #3). Ventilation crews had to carry ladders uphill to the buildings. The ladders were not high enough to reach the roof, so crews had to be content to break as many 3rd story windows as possible.

Inside crews had worked their way to the 3rd floor, extinguishing fire up to the stairwell leading to the attic. Unknown to the firefighters, a boarded up dumb-waiter extending from the basement to the 3rd floor had carried fire directly to an opening under the 3rd floor stairwell, destroying the stairs (Glitch #4). "There we were, fire in the attic and no access. It was a sinking feeling." This meant ladders would have to be carried up to bridge the gap. At 2139 a third alarm was called which would bring a higher ranking officer relieving Chief M of overall command, although he remained in command of the inside attack.

Waiting at the base of the attic for the ladders seemed like forever. It was smokey, hot, and there was no illumination except for their own lamps. One lieutenant, instead of waiting for the ladders, walked up the stair stringers (the side-railing) and made it into the attic with a line. However, Chief M no longer felt that it was safe for him to be in the attic. He was concerned about the roof; he could hear it giving and feel bits of plaster falling. "Mainly it was just the realization that we'd been in there too long. After 15-20 minutes of fire, some part of the structure is bound to give. In this case, it was logical it would be the roof." Instead of obeying the order to evacuate, the lieutenant shouted down "Chief, I got a good spot," to which the Chief replied, "Okay, but don't go any further." At this instant, they heard something fall (Glitch #5) and saw the lieutenant's helmet come flying down the stairs. Fearing that he was trapped or unconscious, the Chief and the two remaining fire-fighters had to walk up the stringers to rescue the lieutenant. It turned out that he was okay, they just hadn't been able to hear him with the noise and through their masks.

Judging that the structure was no longer safe, Chief M ordered all inside companies to evacuate and to begin an external attack. Not long after everyone was out the roof did collapse. After this, they could easily get water on the fire and it was extinguished without further problems. "Basically we knew we were in a good, solid frame structure, so after the roof went we didn't expect anything else to fall. In another structure final operations would have been much riskier."

INCIDENT SUMMARY #4

APARTMENT FLOOR COLLAPSE

This incident began ten years ago as a routine house fire. Although the officer interviewed was not in command of the entire incident, he was in charge of firefighters on the 1st floor of the residence, where he felt the source of the fire was located. Normal firefighting procedures were employed. A miscommunication between the officer and his men and abnormal conditions quickly changed this incident into a life-threatening situation for the officer and men involved.

The initial response to the fire was in the afternoon, Captain L was not the FGC. He was commanded to cover the 1st floor of a 2 1/2-story residence which had smoke but no fire showing. He and his men proceeded to break down the front door and enter the residence, laying out a hose on the first floor.

Within three minutes they entered the living room and went through an archway into another room. Flames could be seen shooting up sporadically in an adjoining room. The Captain ordered his men to hit the visible flames. Flames continued to shoot up from this spot. The Captain then told the nozzleman, "Jack" (who was a diabetic), to go outside and take a break and he relieved him at the tip of the hose.

The room was unusually hot and unusually quiet. The firefighters continued to hit the visible flames, but water was not affecting the heat. The Captain was in the habit of leaving his ear flaps open on his mask. He could sense the intense heat and experience the quiet. "It (the fire) was different enough, it didn't react normally. If you cool something down, it becomes cool and this didn't. The quietness got me. There was something wrong." Capt. L told his men to evacuate. The men said, "Where's Jack, Jack is missing!" as they were going out. The men were unaware that the Captain had told this man to take a break. The Captain thought the man was genuinely missing and remained.

The Captain ran to the window to inquire about the man and ask for another line. Just as he did, the floor in the adjoining room collapsed (where the firefighters had exited) and the Captain jumped out the window. After joining the firefighters outside, Capt. L found out the fire was in the basement and joined the other firefighters in containing it.

INCIDENT ACCOUNT #5

DISTRIBUTED INTELLIGENCE

This was a recent incident (three months prior) and involved substantial property loss. It took place in a large brick building that had been converted from offices to apartments. Battalion Chief V was unaware of the occupancy and had no preplan of the building, yet was able to coordinate an interior firefight relying heavily upon the distributed intelligence of his officers.

At 1800 hours a report of a working fire at an address was received. Chief V immediately responded. Although he was not the first arriving officer, upon arrival he assumed command of the incident. Flames were visible on the 2nd floor of a 4-story building. Firefighters could be seen in the doorway of the building removing an injured citizen. Chief V called for a rescue squad to transport the civilian to the hospital. In the absence of further cues (people at windows or more injured being brought out), the Chief decided to assess the situation for himself.

After the rescue squad arrived, the Chief entered the building and checked with his officer already fighting the fire on the 2nd floor stairway. He knew that the stairway would be crucial should other evacuation be necessary. Chief V asked the men to maintain their position as long as possible. He then left the front of the building and went around back to see how the companies in the rear were attacking the fire. At this point he saw a brick wall which would impede ventilation for firefighters on the 2nd and 3rd floors. He received radio contact from the officer on the 3rd floor. The officer said there was nowhere to push the smoke. Chief V ordered evacuation of the 3rd floor until ventilation could be provided.

Chief V ordered other crews to break 2nd and 3rd floor windows from the exterior of the building. At this point, the Chief went up on the roof of the 1st floor. He described himself as experiencing an increase in stress as the extent of the fire became visible from his vantage point. After ventilation was accomplished, Chief V coordinated the interior firefight. It seems that he relied heavily on his officers situational assessments of the interior to coordinate the companies on the 2nd and 3rd floor.

Additional men and equipment arrived on a hook and ladder truck. Chief V ordered the men to cut a hole in the roof which would provide ventilation. At this point, approximately 20-25 minutes into the fire, bells on air tanks began to go off. The Chief immediately radioed for more tanks to be brought to the scene. Chief V saw flames on the roof. He confirmed this with the officer of the hook and ladder crew on the roof. He also noticed two large billboards above the roof where flames were now visible. He immediately ordered the men on the roof to evacuate.

Chief V realized that the strategy was not working. The fire had progressed beyond the capabilities of his existing manpower. He

called for a second alarm. As the fire continued to burn the billboards became a concern to Chief V. He ordered firefighters to put up a fire line to cordon off the area - safeguarding civilians in case the billboards collapsed.

With the second alarm a higher ranking officer arrived relieving Chief V of command.

INCIDENT ACCOUNT #6

ADULT FOSTER CARE FIRE

The incident took place in June of 1984, one year prior to the interview. Battalion Chief H responded to a residential alarm with a report of people trapped. Despite efforts to save the residents, the lack of knowledge about the use of the residence as an adult foster care facility, the timing of the alarm, and the deadly gases from burning synthetics led to the loss of three adult women.

The initial alarm was sounded at 2200 hours, with a report of people trapped in the residence. Due to recent changes in the department, Battalion Chief H would be working with a number of inexperienced fire fighters.

Upon arrival at the scene, flames from a 2 1/2-story house were visible from the street. Battalion Chief H immediately coordinated the parking of apparatus and began his size-up. He walked to the side of the house and saw blood on the side door and flames in the back of the residence.

He quickly ordered a line to the front of the residence and six firefighters to begin search and rescue procedures on the 2nd floor of the residence. Four firefighters were used to search, and two to ventilate. Within minutes, two women were located on the second floor and removed from the residence. Efforts at resuscitation were begun immediately.

About two minutes later, a neighbor informed the Chief that another woman lived at the residence and might be inside. The Chief immediately sent the rescue squad to the third floor of the residence. Within three minutes, the resident was located and removed from the house. None of the occupants could be saved.

Containment was reached five minutes later. Although the residence was being used as an adult foster care facility, at the time of the blaze no supervisor was present in the home. The Chief felt that the nature of the residence was a factor in the loss of life in this incident. Chief H felt that the adult residents did not respond as normally functioning adults would have.

The fire was caused by a cigarette in the downstairs area of the home. It was later discovered that the blood on the door was from a visitor - a boyfriend of one the residents. Both he and the woman fled the house when the fire began. They were later found at a local emergency room receiving treatment.

INCIDENT ACCOUNT #7

CLOTHES CHUTE

This incident took place in 1981. It is of interest because the initial size-up was incorrect, because it was incomplete. Subsequent attempts to direct the operations toward the reality of the fire were too little, too late. Strategy had to change from fire control to search and rescue (evacuation) within several minutes after arrival of firefighters.

It was the third week of December and temperatures were below freezing. Snow fell heavily, adding to the few feet of accumulation already on the ground. A civilian call came in about 2030 hours that there was a fire in the basement of an apartment complex. Arriving at the scene of the call about 5 minutes later, an engine not more than a half minute behind him, Captain L immediately radioed to the dispatcher that the structure was a 4-story brick building with, "nothing, showing," i.e. no smoke or flames apparent. The Captain was familiar with this type of apartment building structure, so he and his driver went around the side of the building to gain access to the basement through one of the side stairwells located at either side of the building. Trudging through the accumulated snow, they finally made their way to the basement where the Captain inspected the floor and saw immediately the clothes chute as the source of the fire.

Looking up the chute which ran to the top floor, he could see nothing but smoke and flames. The duct was of thin metal but with a surrounding wooden skirt throughout its length. Visibility was poor because of the engulfing flames and hampered the initial appraisal of the amount of involvement. Nevertheless, upon the assumption that the civilian call came close in time to the start of the fire and that their response time had been quick the Captain instantly assessed the point of attack to be at least the 2nd floor clothes chute access point. At approximately 2037 hours, the Captain came back out of the basement and told his driver to radio that they had a working fire.

Meeting the first arriving firefighter crew, the Captain told a lieutenant in charge to take a line into the building. The Captain was not specific as to where the lines should go, but his intention was to start at the 2nd floor. Acting on his own initiative, the lieutenant led his crew and the first hose into the 1st floor. The dispatched crew shortly thereafter sent word that the fire was already beyond that point. Another line was ordered to go to the 2nd floor, within some tens of seconds after the first hose order. This second line crew sent word back about a minute later that the fire was beyond the 2nd floor also. A third line was ordered to go to the 3rd floor because the firefighters had dropped their first lines at the initial ineffectual sites as their standard practice. About three minutes had now elapsed since the Captain's arrival. The report then came back that the 3rd floor was also involved.

The Captain had made his way to the front of the building. Unexpectedly, he saw flames rolling along the ceiling of the 4th floor landing of the glass encased front stairwell, external to the

building. Immediately recognizing that the fire must be quite involved, the Captain switched his strategy to protecting the front egress for the now prime objective of search and rescue operations. He quickly dispatched his truck crew to do search and rescue on the 4th floor and then radioed for a "triple two" alarm, to get the additional manpower to evacuate the entire building and fight this new front. Seven minutes had now elapsed from the first call of a working fire.

The Captain considered where he would deploy the new units from the alarm only after he had completed the call. The fire would now have to be fought by pushing the fire down the 4th floor hallway (from the front towards the back), all the while protecting the front staircase as the evacuation route. Capt. L realized that his two engine squads' lines were engaged in the back and that it would take more time for his men to pull these fully charged lines to the front than it would to get new equipment and manpower at the scene.

Upon arrival, the new units were ordered to protect the front staircase, lay lines to the 4th floor to push the blaze back down the hall, and to aid in search and rescue of the entire building. Capt. L turned over responsibility for the evacuation operations to the Battalion Chief and his assistant who arrived with the triple two alerted units. Approximately twenty people were eventually evacuated and the total time to containment was about an hour.

INCIDENT ACCOUNT #8

TRAPPED FIREFIGHTERS

This fire had three phases. In the first, the attempt was to control it to the back portion of a reconverted mansion. When that failed, the second phase was to put it out as quickly as possible on the 2nd floor of the front of the mansion. In the final mop-up, the Battalion Chief and his boss, the Assistant Fire Chief went on the 2nd floor to supervise and found that the fire was climbing up the only stairway. In the third phase, they evacuated the building through 2nd floor windows, and fought the fire from the outside, leaving a ruined building that was eventually demolished.

The fire had occurred approximately 2 months prior to the interview and involved an old mansion that had been converted into apartments. The fire began in a rear building, formerly a servants' quarters. It was probably an arson fire. The first units pumped water from the outside. The chief's strategy was to obtain additional support, come in through the main building and push the fire out the back, keeping the main building intact. This strategy failed. The interior was too hot and his troops could not make progress through the ground floor to get up to the 2nd floor. The fire was probably spreading through the cockloft into the front portion by this time, although he did not know it.

He ordered additional help, and also rescued two people from the 2nd floor of the front portion of the building. He also ordered the ventilation of the front building, to allow the heat to escape. He could now see smoke in the eaves of the front portion and knew that it was getting into the attic. He had the hook and ladder men chop a hole in the roof, to relieve the heat. This appeared to work. He sent men into the building again, up to the 2nd floor, where they had the fire contained. He and the Assistant Fire Chief went up to the 2nd floor to supervise. The ceiling to the attic was pulled down, showing no fire. They were 95% sure that it had been extinguished. Then they saw it coming up the stairway. They divided into 2 groups, half went out a window in the front, onto ladders and the other half went onto a garage roof in the back. There were no casualties. They finished up by hosing it down from the outside for 15 minutes, extinguishing the fire but leaving the house unsalvageable.

The Chief had misread the fire's progress in the front portion of the building. He had no cues until his men tried to enter the front of the building and were driven back. Then he began to suspect that the fire was invading the front of the building, and switched to a scenario of fighting it there: by ventilating the front, knocking windows out, chopping a hole in the ceiling, looking for evidence of fire in the attic. This scenario worked, and they controlled the fire, except that it was spreading through a space in an internal wall, down to the 1st floor. (There was a chance that the arsonist had set up a second site for the fire, but that this did not ignite as it was supposed to, until the natural spread of the fire set it off later.) This is how they were trapped. As soon as they realized they had been fooled, they switched into a third scenario:

evacuate quickly and safely, and give up on controlling the fire. Once the evacuation was completed, they fought the fire from the outside and put it out quickly, but the major damage had already been done.

At each of the major choice points, the Chief used the available information to focus on a scenario. There was no evidence of weighing options or worrying about alternatives. The shifts occurred because important information was not available until too late.

INCIDENT SUMMARY #9

OVERPASS RESCUE

The Lieutenant heading the Rescue Squad was called to aid a woman lying semi-conscious, draped over the crossbars of a superstructure holding a sign over a highway interstate. She had fallen there from an overpass. His men climbed out to hold onto the woman, and the key decision was about how to attach a harness, strap, or belt to her in case she fell. There were five choices, only four of which were considered. None of the ones considered were workable. The only effective choice was the one not considered. Nevertheless, the woman was safely rescued. The strategy of deciding was an example of growing a decision.

The event occurred 6 months prior to the interview, during the winter of 1985. The Rescue Squad was called out during the evening, at approximately 2240 hours, for a woman threatening to jump. Upon their arrival a civilian directed them to the woman, who was lying semi-conscious, draped over one of the 3-inch metal bars holding up a highway sign, over an interstate highway. The woman was possibly drunk, drugged, or injured. The officer in charge stated that his main concern was for the safety of his men, to make sure they were secured before risking their lives. Nevertheless, two of his men set out without safety ropes, climbed down, and positioned themselves at her head and feet, securing her just before she started to slide off the bar. If they had waited to secure themselves first, it might have been too late.

A hook and ladder truck arrived, and he ordered it to get onto the interstate, below her, to block traffic in case she or one of his people fell, and also to raise a ladder to help with the rescue.

The immediate need was to secure her to the superstructure with a rescue harness. He considered four choices: Kingsley harness, Howd strap, upper portion of the Howd strap, or ladder belt. Because of her face-down position and the risk to his troops, he rejected the first three choices and picked the ladder belt -- a simple device that required only one buckle and could be easily attached without moving her. This was tied to a rope. Improvising further, he attempted to have his troops fix a Howd strap to her upper body, to make a sling they could use to raise her to safety. However, his troops could not understand his directions. At the same time, the hook and ladder truck had arrived and the ladder was extended with two troops on it.

The woman started slipping off the bar, and the officer decided to let her slip, guided by the ladder belt, onto the ladder. At this point, the problem with the ladder belt was found--it was too large. The ladder belt is made to tie around the waists of firefighters, and to snap onto ladders, thus securing them during rescues. It is made to fit firefighters wearing fire protection coats. Even at its tightest setting, it is too large for a slender woman in a skimpy jacket (which also slid off of her). The woman was completely slack, and slid right through it. As the Lieutenant said, "she was just like spaghetti." Fortunately the ladder was just below her, and the troops

caught her and made the rescue.

In reviewing the procedures the next day, it was found that all four options were defective. The only workable choice would have been to tie a rope around her wrists. This had not even been considered.

INCIDENT ACCOUNT #10

CAR RESCUE

This incident involved a rescue from an automobile approximately two years prior to the interview. It involved using a newly acquired scissor attachment to the jaw-of-life tool and a procedure for removing the roof from the car. The firefighters had heard of this procedure, but had never tried it. An unexpected retirement had caused a temporary shift up in the command structure, so firefighter D was Acting Lieutenant of the rescue squad.

A dispatcher call came in at about 0100 hours to assist at an accident site on an interstate. The squad arrived at the scene about seven to eight minutes later; no other information had been made available to the crew on the way. The roof of a damaged, but upright, 2-door car was almost completely severed from the body. The incongruity of the roofless automobile with roof posts still visible struck the firefighter as he made his way over to the car. He saw that the driver was still inside but slumped over; no other passengers were inside. His first action was to try the driver's door to get the man out, but it was jammed shut. He called to firefighters on the scene to try the other side, but it too was jammed. The chief of the engine already on the scene, and other officers also present, yelled to get the jaws-of-life to extricate the man.

Acting Lieutenant D continued his size-up and pushed the hanging auto roof to one side to look down on the driver. He began to conceive a plan of lifting the injured person through the top of the car. Although he had never performed such a rescue, he had heard others describe actually undertaking such a rescue successfully. The Lieutenant called to his squad to fit the jaws-of-life with the newly acquired scissors attachment. A body board was also ordered to be brought. The lieutenant had now completed his scenario for action; he mentally configured the operation of lifting the man through the roof of the car and knew where he wanted the body board to be placed for the victim when he came through the top. From arrival on the scene until this point about five minutes had elapsed.

Members of the rescue unit scissored off the roof and the Lieutenant then attempted to lift the injured man through the roof. The driver's legs, however, were wedged under the dash and other firefighters were needed to unlock the knees of the man so the Lieutenant could continue lifting the man by the shoulders out the top. The Lieutenant requested that the body board be placed near the man as he came through. The driver was safely extricated without further incident. (Another four minutes had elapsed, but the operation was complete.) The driver was then evacuated to the hospital.

INCIDENT ACCOUNT #11

TRAPPED FIREFIGHTERS

The incident chosen occurred 2 months prior to the interview. What seemed to be a rather routine firefight quickly changed into a life threatening situation. The officer interviewed was a lieutenant of a very busy engine company. A Battalion Chief is regularly attached to the house so the lieutenant is never the FGC and seldom the first arriving officer.

At 0100 hours engine company #1 responded to a special alarm, a working residential fire. Upon arrival, Lt. D saw a lot of fire showing in the attic and in the rear of the house. The FGC ordered Lt. D to take a line to the attic where 2 or 3 other companies were already involved in "knocking down" the fire.

After the fire in the attic was pretty well contained, Lt. D was ordered to bring his line down. By this time, his men were just about out of air. They were removing their masks, as they reached the second floor. Suddenly there was a flash on the second floor. The nozzleman hit the flames but immediately lost water when the line burned.

Lt. D checked the only exit he knew (the way he entered the building), it was blocked by fire. Quickly the Lieutenant crawled along the side wall until he felt a window, hoping that he wouldn't mistakenly enter a closet or bathroom. He radioed for a ladder to the window. Sounds of other officers radioing for ladders alerted him that others were also trapped. When he was sure he was at a window and could see ladders out the window, he began calling for the men. By following the sounds of voices, men made their way to the window and out of the flames to safety. Lt. D asked the Chief to stay near the window while he went back to see if everyone was out. With no visibility, the Lieutenant was able to follow the Chief's voice to get out.

Lt. D summarizes the incident well: "You have a very limited view of what's going on. I thought we were doing a heck of a job of knocking the fire down. But here the other half of the house is going. That's the Chief's job, to notify us of what's going on."

INCIDENT ACCOUNT #12

ARSON-HOUSE FIRE

The incident chosen occurred two months prior to the interview. Capt. F chose this incident first in a series of three. His interest in the fire appears to be based upon the initial aggressive attack his crew waged upon an arson-murder fire. The Captain's familiarity with the neighborhood's social problems and the types of homes in the area allowed him to "preplay" or imagine some critical factors prior to arrival on the scene.

At 2300 hours the task force received a report of a working fire on the 2nd floor of a 2 1/2 story house. Within a minute (while on route) the officer could see a glow in the sky. Capt. F reported that he began to imagine what the residence looked like and the most expedient ways to gain access. At that hour in this particular neighborhood he knew he would likely encounter homes reinforced against intruders (boarded, bolted, etc.). The neighborhood is known to have a large amount of drug traffic and arson. Residents commonly reinforce doors/windows hindering firefighters' efforts.

Upon arrival, three minutes after the original alarm, the officer saw fire showing from the front door and upstairs windows. Immediately he was informed by citizens that a woman was trapped upstairs. Beginning search and rescue strategies the Captain immediately ordered forced entry at the rear of the residence and a line to the front door. The Captain and three other firefighters forced entry at the front door. The stairway was encased in flames. Capt. F called for a handline to advance up the stairs. Before entering the residence Capt. F told the pump operator to have the next crew protect the exposure next door which was threatened due to wind and the intensity of the fire.

Within a minute, the firefighters and Capt. F found a woman laying on the kitchen floor at the top of the stairs. She was the first of three citizen fatalities, two males not known to be in the residence were also found.

Capt. F felt the obvious source of the fire was arson. The rate of burn, the location, and the direction of the flames were key factors in his assessment. He was keenly aware that fire with the intent of murder is often used in retaliation by local drug dealers and residents.

INCIDENT ACCOUNT #13

DANCE HALL FLOOR COLLAPSE

It should be noted that for this incident timeline details were difficult to obtain. Although three separate interviews were obtained from this officer and probed, in none did the officer seem able or willing to take the "play by play" perspective that we attempted to obtain. It was as if each incident were encoded in terms of a single key experience and all other aspects of the incident were downplayed, either lost or found "uninteresting" in terms of his interview style.

In this incident, which occurred approximately one year prior to the interview, Capt. F and his crew attempted to fight a fire in the basement of a large single story dance hall. His key decision was to evacuate himself and his men just minutes before the floor of the structure collapsed. Capt. F chose this incident as an illustration of what he called a "sixth sense".

The alarm came in at approximately 2400 hours. The first thing Capt. F recalled was seeing a large single story structure known to be a dance hall and observing flames through openings in the basement windows. The extent of the fire was difficult to judge because almost 90% of the basement window openings had been bricked up. He saw flame briefly and sporadically for a few seconds, then for a time only smoke was visible. He ordered his men to hit the fire from the outside through the basement windows. Once the water hit the basement the smoke built rapidly. Still the extent of the fire was uncertain.

After a brief delay, the hook and ladder company arrived and was ordered to gain access through the front door of the building. Once the door had been forced open, the smoke built significantly. This was a cue that there was an extensive fire present.

Three firefighters and the Captain went inside with a hand line. It was dark and almost nothing could be seen. Kneeling down they could feel that the floor was very warm and realized that they were on a wooden floor. As they moved further into the building, they could feel the temperature rising and hear the fire crackling beneath them. Movement was difficult because it was so dark and the hall was filled with tables and chairs which they kept tripping over. They finally reached what they judged to be a stage area and found some stage doors which they then opened. They could still see nothing but could feel the room getting hotter still. At this point, some 15 to 20 minutes into the incident, Capt. F reported "A strange feeling like being totally alone, even though I knew the other guys were there." At this point he ordered his men to evacuate and within 2-3 minutes the entire floor collapsed.

INCIDENT ACCOUNT #14

CELLAR FIRE

This year old incident was chosen because it was in a concrete cellar with no windows, making normal ventilation impossible. Therefore, the fire had to be fought in large amounts of smoke and intense heat, making this a highly stressful fire in the judgment of the lieutenant in charge.

Lieutenant F received the call via radio that there had been a report of smoke in a market at a downtown location. He and his engine crew were returning from an inspection tour and were asked to respond, as they were already in the vicinity.

The engine arrived at the fire sight in approximately one and one-half minutes. Smoke was seen coming from a restaurant attached to the market. The owner of the restaurant informed the lieutenant that there was a fire in the cellar part of the market, below the basement, which some employees were already attempting to control.

Lieutenant F went to the cellar, three floors down, to investigate and found the employees putting water on some smoldering boxes, but "not doing much good." The Lieutenant comments, "Fire is funny, it may seem like a raging inferno in one place, but that's not really the problem. There it's only temporary or whatever, where the real problem is over there which doesn't look like much."

At this point the Lieutenant realized he had a working fire and had to run back the three flights to get the hose and his crew. By the time they got back down to the cellar "within a few minutes," the heat had increased noticeably and the smoke was looking blacker, indicating that the fire was probably burning plastic material contained in some of the boxes. Because smoke from plastics is toxic, the order was given to put on masks and search for the source of the fire. Two employees directed the crew down a hallway located "just around the corner." Unfortunately, the hallway was some twenty feet from where they understood the employees had directed them. They had a very difficult time locating the hallway. It was dark, and they kept bumping into solid wooden lockers everytime they turned down what they thought was the hallway.

At this point, the fire was described as highly stressful. These were concrete walls and the fire had been smoldering along time. It was very dark and very hot and getting hotter by the minute. By this time the truck crew had arrived, but they had no place to ventilate, "so the place was just filling up with smoke and getting hotter, so hot that you couldn't even kneel on the floor." It took five to six minutes to go less than a hundred feet, "which seemed like forever." The Lieutenant realized that had this this amount of heat been in a wooden fire there would definitely have been a flashover. "I guess it's a different kind of stress than worrying about a floor collapsing, everything was very solid at least".

This fire was unique in the officer's experience in that no way was found to ventilate the cellar. The truck crew brought down fans and tried to draw the smoke up the stairs, but this was almost totally ineffective.

INCIDENT ACCOUNT #15

LUMBERYARD FIRE

This incident occurred a few days prior to the interview. The officer interviewed was promoted to Captain two months ago. Although not the Commanding Officer, the Captain was in charge of a task force consisting of twelve firefighters and four pieces of apparatus. This was his first major fire since achieving this rank.

At 2300 hours the task force had received an alarm for a garage fire. As they were cleaning up after this fire, another alarm was sounded to a large lumberyard in their service area. The firefighters were wet and tired; however, Captain H decided to hurry them along when he heard additional alarms sounded at the lumberyard location. He knew that as soon as he could put the task force back in service, they would be sent to the lumberyard.

Within minutes of this decision they were back in service and dispatched to the lumberyard. Upon arrival, the Captain directed his firefighters to stay with the apparatus until he received orders from the FGC.

The chief in charge of the incident directed the Captain to set up the hose and find a source of water. Water was a major problem in this incident. Poor supplies of water with bad water pressure were to severely limit the efficiency of the operation.

The Captain found a supply of water one block from the scene of the fire. He ordered the men to hook up the supply pumper and relay the much needed water to the scene. Shortly after hooking up, the Captain realized that the water source was not only a poor one but that he was affecting the water supply to nearby apparatus by using this source of water. Shortly after hooking up to the hydrant, he ordered the supply pumper shut down until a better source of water could be located. Captain H then sent the attack pumper from the task force to the next street away from the fire scene to seek water.

It was a windy night. The intensity of the fire, coupled with the weather conditions, created a threatening situation for three residences and a business bordering the lumberyard. Captain H saw the building next door begin to smoke. He yelled for a gunner to hit the building.

At this point the Battallion Chief made the decision to protect the threatened exposures rather than extinguish the lumberyard fire. Captain H and two of his firefighters left the pumper to see what they could do. Captain H told the pump operator to stay with the apparatus. A civilian informed the Captain that a baby was in one of the houses that was being threatened by the blaze.

Captain H decided to check all three residences to make sure that the inhabitants were evacuated. The first two houses were found to be empty. At the third house, the Captain encountered a man who said the baby was his and was not in the house. The Captain checked the

residence anyway.

As the Captain returned to look for water, he assigned one of his firefighters to watch the houses on the street and evacuate if necessary. There were a lot of flying brands (burning material) threatening to ignite nearby residences. A telephone pole burned and broke in half, pulling large cables down with it. A girl was struck to the ground by one of the falling cables. Captain H assigned two of his firefighters to pull her out and put her on a backboard so that she could be transported by EMS to the hospital. Captain H did not know if the wires were live or not.

Due to the lack of water resources, many firefighters were on the periphery of the fire wandering around and watching. The assistant chief ordered the Captain to gather up as many of these men as he could to set up lines to a nearby building threatened by the fire. The lines were quickly set up. Captain H, aware of the low water pressure, noticed smoke coming from cracks in a brick wall. Thinking that the wall could fall down, he ordered his firefighters to move themselves and the civilians back thirty feet.

By daylight, the fire was contained. Captain H then began dismantling and rearranging the massive relay system that had been constructed to accomplish containment. It was his job to decide which pumpers would be put back in service and which would stay. The next shift of firefighters came to relieve these men and clean-up operations continued well into the evening hours.

INCIDENT ACCOUNT #16

HOTEL FIRE

This incident occurred 15 years prior to the interview, but stuck out in the officer's mind as a time when his decision made a critical difference in the outcome of a serious hotel fire.

The alarm came in as an observation of smoke on the 8th floor of a downtown 9-story hotel at 0200 hours. The late hour would indicate that guests would be in their rooms asleep, although Chief W reported that initially the call was not viewed as critical. Such alarms are received fairly frequently and usually result in only a minor incident. In approximately 3 minutes his staff car had arrived at the bridge about 1/2 mile from the hotel, and Chief W could see a large volume of smoke coming from the 5th floor of the hotel. He concluded that the 8th floor report must have been secondary smoke. Immediately the magnitude of the threat to life was evident, and Chief W's stress level peaked to perhaps the highest level he had ever experienced in his career. Chief W mentally reviewed the structure of the hotel, which he had learned during a recent inspection tour: open interior stairwells would provide a chimney for the fire, and in the hot night many windows would be open providing ventilation for the flames. He could only expect the worst. Chief W also recalled the location of the hallway standpipes, and this knowledge greatly aided the success of the operation.

At approximately 0205, Chief W and the southside Battalion Chief arrived simultaneously at the scene. It was customary for the first arriving officer to take charge of the inside, with the second company taking charge outside. In this case, the rule was not applied. The southside Chief was an older gentleman and offered Chief W the inside.

Within approximately 2 minutes, Chief W had reached the 5th floor landing and could see smoke coming out from around the fire door. By the amount of smoke and the blackish color (from burning carpet and materials) Chief W inferred that the fire was going to be extensive and that it would be risky to try to use the 5th floor standpipes. He instead decided to use the 4th floor standpipes and stretch them to the 5th floor, a decision which turned out to be absolutely correct. The 5th floor standpipes were later found to be totally unusable.

Immediately after he made the standpipe decision, he ordered a second alarm. He knew that the ladders would not reach the 5th floor and would be of no help during rescue, so his primary goal was to ensure an exit for the trapped victims on the 5th floor. He radioed for the incoming crews to enter through the main lobby side of the hall, so that he would have a two-pronged attack.

The fire was contained within 15 minutes of arrival, and only one person had to be hospitalized for severe smoke inhalation. This was considered a highly successful operation.

INCIDENT ACCOUNT #17

DOWNTOWN BLOCK

This fire, which occurred six years prior to the interview, was chosen because it was one of the largest fires in this officer's career, and one of the most disappointing. "This fire beat us. It burned itself out, we didn't put it out." It illustrates how quickly a fire situation can deteriorate, causing a switch from an offensive to a defensive strategy.

The call came in just prior to 2400 hours. Chief W was not with the first arriving companies. He was an Assistant Chief riding with the Battalion Chief that night. The report had been of heavy smoke in the basement of a bar which was on the 1st floor of an 8-story brick building at a central downtown location. Only minutes after arriving on the scene, the first arriving officer, a lieutenant, came up from the basement to tell the Chiefs, "I think we got it." Seconds later, Chief W looked up and saw smoke puffing out of the elevator shaft at the top of the building. Just as he thought about getting up there to ventilate, the whole top of the building burst into flames.

Chief W called a second alarm and minutes later a third, but the fire was now an inferno burning in the tops of two of the adjacent buildings downwind of the 8-story source of the fire. Within minutes Chief W realized that the fire could not be extinguished and ordered defensive moves designed to contain the fire at the alley at the end of the block (5 stores down). Fortunately, the third building which caught fire had a fire wall which successfully stopped the fire there. "We had nothing to do with stopping that fire. Without that fire wall, we would have lost that block."

INCIDENT ACCOUNT #18

RENOVATION FIRE

The incident took place last winter. It was of interest to the chief because it was the largest incident he ever commanded. Although there was not a threat to firefighter or civilian lives, the officer in charge found the staging of men and equipment challenging.

The alarm came in about 2330 hours to a hospital known to be empty and undergoing renovation. The first arriving officers had radioed for two more engines. Seeing the sky aglow and hearing the call for additional engines prompted the chief to call a second alarm while on route to the fire.

The other arriving chief took the rear of the building. When the chief arrived he could see approximately 150 feet of one wing of the building engulfed in flames. He could not see the back of the building but the attic was fully involved. When the rear sector reported construction and limited access in that part of the building, the chief decided to set the command post in the front of the building.

The next ten minutes of the blaze involved laying lines to begin the attack. The chief, at the rear of the building, reported that the fire had moved two hundred feet during this time.

As more apparatus and manpower arrived, the chief was primarily concerned with the placement of men and equipment. Firefighters were used to check water sources outside the immediate area. Over fifteen apparatus were used to contain the blaze which became a general alarm. The general alarm brought more chiefs and the blaze was finally sectorized in four areas, taking four and one half hours to contain.

INCIDENT ACCOUNT #19

DOWNTOWN GAS LEAK/EXPLOSION

This incident started as a routine report of an odor of gas in a downtown alley, and ended up requiring response to a house explosion and the evacuation of approximately six square blocks of downtown dwellings, including a nursing home. This was a case in which size-up had to be continually modified as the seriousness of the situation gradually unfolded.

Initial response to the midnight weekend alarm was a single engine and a truck and the Acting District Chief, Capt. H, who assumed command. Reports of gas leaks are frequent and generally so minor that the call was treated as totally routine ("... you finish your sip of coffee and tip back your hat before you 'rush'"). Capt. H smelled the gas some two hundred feet from the reported location scene and heard a faint hissing sound. His reaction was that this leak must be larger than usual, although his concern was still not great. Acting on the possibility of a serious situation, Capt. H requested that the utility company be called and informed of a potentially serious situation, and that two additional engines be called to fill out the full alarm response. These engines arrived at 0008, with one engine being positioned outside of the vapor area and the other engine placed closer in with its engine shut off to prevent it from becoming a source of ignition. At this time, Capt. H called for an EMS squad. This reflected his growing concern that a serious situation could develop.

One factor which increased Capt. H's rising level of concern was the fact that the utility company did not have anyone available to send, and had informed dispatch that, "it's going to be awhile." In addition, Capt. H felt that most of the firefighters were underrating the potential seriousness of the situation. Capt. H credited his more realistic concern to the fact that he has been involved in several serious gas leak incidents previously. However, Capt. H related that he, too, was still torn between making decisions in relation to a worst- or best-case scenario.

At approximately 0011, Capt. H ordered an engine deck gun and a moveable deluge gun into position to spray the vapor area. This action was apparently non-procedural. The standard response to a natural gas fire is to "stop the flow of gas only" (NFPA Fire Protection Handbook). However, the use of a waterfog stream has been recommended to dissipate gas in populated areas (Emergency Action Guidebook). When asked to defend his action in the subsequent incident critique, Capt. H explained that his action accomplished two things. First, the spray helped to locate the source of the leak by making the vapors "visible." Second, the vapors were used to disperse the vapors away from a residence (Dwelling A) located just east of the leak. (The wind had been blowing west to east at five to ten miles per hour.) Capt. H related that this decision was made on the basis of his fairly extensive previous experience with gas leak incidents. He had apparently seen this technique successfully applied.

An investigation revealed that the leak was in the main line below the valve indicating a potentially serious leak. Crews were ordered to evacuate houses in the area, while checking for the presence of gas and shutting off possible sources of ignition. Dwelling A was vacant, and a search was made for the person who was said to have the key for the people on vacation. This key was never found and eventually a forced entry was made. Capt. H related that this careful quest and search for a key contrasts with the popular image of "firefighters as ax wielding morons." In hindsight, however, he feels he should have forced entry earlier and that this hesitation reflected his resistance to view the situation as the worst-case scenario it was to become.

Approximately one half hour after midnight, gas readings were beginning to show vapors in an extended area, including a nearby nursing home. At this time, Capt. H began to set up formal sectoring including an evacuation command, and the police were called to aid in the evacuation. A liaison officer was designated to handle communication between police and firefighters.

At about 0100 hours utility company crews finally arrived; however, they estimated that it would take four to five hours to shut off the gas and repair the leak, partly due to undermanned weekend crews. At this point, Capt. H reported that his stress level became quite high, and he felt the need to step back from the scene. He stepped into an alley to compose himself and to plan his next action. He felt at this point that the utility company was seriously under responding to the incident, yet he had no direct control over their activity. He labeled this his greatest source of stress.

From 0100 to 0130 hours, the evacuation of the area continued with a high priority given to the elderly housed in the nursing home. Eventually, a hundred and sixty people were evacuated to a designated evacuation center and ten were removed to local hospitals. At this point, Capt. H describes his command function as that of a supply clerk, "you tell me what you need and I will get it for you." He described a very high confidence in the functioning of his crew.

At 0130, Dwelling A exploded and started to burn. Capt. H immediately called a second alarm response to be staged. This action enabled four engines and a truck to be available and included a call for the central division chief to arrive. Crews already on the scene were ordered to attack the fire, and fire control efforts were very successful in extinguishing the fire quickly and efficiently. The original hose lines which were laid at the leak source for the fog stream were utilized and it was felt that these lines facilitated the success of the operation.

Surprisingly, Capt. H reported that the dwelling fire perhaps served to reduce his overall stress, as it provided a focus for his command and charged his men into action. At approximately 0150 hours, Chief A arrived with the second alarm and relieved Capt. H of fireground command.

The long, complex, and dangerous incident was handled with no loss of life and no serious injuries to either civilian or fire personnel, and was judged to have been handled properly and professionally in a Dayton Fire Department critique of the incident. One problem of interest to us was an identified lack of a clear command structure. Capt. H was cited as doing a good job in delegating tasks and not trying to do everything himself, but he apparently did not keep an accurate written record of who had been assigned to each task. Also, he did not formalize the command structure and delegation by assigning one member clearly as each sector commander and designating his title. On a small and uncomplicated incident, this might not be a major problem; but, if an incident is large and complicated, this lack of structure could quickly escalate into a serious problem.

A second problem was with radio communication. Radio channel 3 is designated for intra-fire ground command communication. However, this channel was under used as over 50% of the radios had difficulty receiving this channel. This apparently caused an overuse of channel 2, which could conceivably override channel 1 and cause dispatch communication to fail.

INCIDENT ACCOUNT #20

HOTEL FIRE

This incident occurred one and one-half years prior to the interview. It was perhaps one of the largest and most life threatening fires in the city's history.

The fire involved almost the entire 3rd floor of a 3-story downtown hotel on a weekend night. Twenty-nine people were rescued. Although one victim later succumbed to smoke inhalation, rescue efforts, as well as fire control operations, were judged to have been very successful and a credit to the department's efficiency. Perhaps the most striking aspect of this interview, from the point of view of this study, was that in an incident of such magnitude the fire ground commander, Chief H, could recall almost no direct orders that he gave. He instead recalls himself as a monitor and supplier to ongoing activities which were being carried out by lower level officers and firefighters who could see what needed to be done and proceeded with rescue with the utmost speed. In Capt. H's words, if men must wait for orders in a situation such as this, the battle would be lost. Although this was perhaps the first major rescue operation for 70% of the men involved, training and pre-planning was credited for the success of the operation.

The alarm was sounded at 0301 hours as a report of a fire at a downtown hotel. There was no immediate information given which would indicate the extent of the fire and Chief H recalled feeling no great concern initially, "We move the same, regardless." However, within 3 blocks of the hotel the first engine radioed that they could see fire coming out of the rear and requested permission to stage an additional engine and call the medic squad. Permission was granted, and although it was clear the incident would be a working fire in an occupied structure, Chief H was still not experiencing any undue stress. He reported that he was expecting the fire to involve a single room.

It was a shock when the companies came close enough to see the hotel in the dark and "people hanging out the windows everywhere" (approximately 10). At this moment, stress was perhaps as high as Chief H had ever experienced, but only momentarily. Within minutes Chief H called a second alarm. Lines were laid and rescue operations begun. The decision to call a second alarm was made with virtually no deliberation, as Chief H wanted to ensure that there was enough manpower to handle rescue even before considering fire control operations. Rescue operations proceeded without direct commands by Chief H who saw himself as "monitoring" rather than "directing" events as they occurred. As soon as lines were laid and all available manpower was involved in rescue (approximately 5 minutes), Chief H called a third alarm plus special medical units and was relieved of fire ground command by the arriving assistant chief at approximately 0340.

The incident was judged to have been exceptionally well handled with no significant mistakes detected. Twenty-nine people were taken from the hotel. There was only a single civilian death due to smoke

inhalation, and no major injuries to firefighters. Chief H compared this incident to a Las Vegas hotel fire which had recently occurred where several people had died. In a case like this "fatalities" is the primary measure of success. Fire control efforts seem to be considered only secondarily and Chief H appeared to have little interest in recalling or relating fire control operations.

INCIDENT ACCOUNT #21

DECEPTIVE STRUCTURE

This was a recent incident (less than 1 month prior to the interview) which was chosen because of several unusual aspects; 1) a difficult size-up because of a deceptive view of the structure, 2) a poor water supply, 3) an unfamiliar Chief, which made it difficult to communicate important aspects of the fire scene, 4) incomplete knowledge as to the contents of the structure, and 5) a greater than usual number of firefighting skills were required to gain access and fight the fire.

The alarm came in at 2135 hours as a sighting of smoke in the vicinity of named cross-streets. The vicinity was immediately identified as a warehouse and factory area to which frequent calls are made, usually involving one of many piles of debris. The day was Sunday, making it even more likely that no real hazards would be encountered since the area would be shut down. Upon arrival, however, (2136 hours), the front of a 2-story brick building, labeled as a molding company, could be seen to be fully involved. As a precaution, the first arriving officer, Capt. H, called for two additional engines to be staged (2137 hours), primarily because this area was known to have a poor water supply. Still, Capt. H saw nothing to indicate that the fire would not be easily controlled. And, in fact, by the time the District Chief, Chief A, arrived (2141 hours), the fire had been pretty well knocked down in the front part of the building.

Capt. H turned over incident command to Chief A joined his crew on the roof. It was then that the deceptive aspects of this fire began to unfold. His first clue came as he climbed to the roof and called out to his driver, whose answer "sounded very far away". From the roof he could see another 75 x 125 single-story section extending behind the front 2-story section, which was completely hidden from the front. A crewman reported that he'd punched holes in the roof and gotten fire and that this part of the roof felt spongy. Capt. H verified these facts for himself, "Every hole we punched we got fire... forceful fire, like water pushing out of a hose straight up... which indicates a tremendous volume of fire inside the building from something other than normal combustion (i.e. wood, paper)." At this time he had no idea of the contents of the building, but could suspect some form of plastics or hydrocarbons, although he did not see the characteristic black smoke.

He radioed to Chief A. this new size-up and his decision to abandon this section of the roof. Radio protocol demanded only a few short facts. However, Capt. H had a new awareness of how large the building was, how forceful the fire away from the front area, and the sponginess of the roof. Capt. H felt he had adequately conveyed that "This fire is not what it seems...all hell is breaking loose up here." Chief A's response was a simple "command clear," which was not the response Capt. H was looking for. Capt. H did not have a lot of experience working with Chief A and he was concerned that the Chief might not understand or "believe" his assessment of the situation. Therefore, he decided to come off the roof and reiterate his findings

'face to face' with the Chief. Immediately after going over his report again with the Chief, visible smoke could be seen coming from behind the 2-story section, and that in combination with the report, convinced Chief A that a second alarm was needed (2155 hours). Capt. H believed that this communication problem was primarily the result of their not having worked together a great deal. "With my regular Chief, a few key words would have been all that it took."

An interior attack was attempted on this middle section of the building. Access to the building was gained only after cutting through several padlocked fences, then forcing a garage door and pulling out a truck. The interior of the building had a long fire wall, a concrete wall with two sliding steel fire doors, which had kept the fire from spreading down the length of the building. "Inside those fire doors was like looking into a blast furnace." It was later discovered that the building contained plastics in many of the boxes that were burning. This partially accounted for the unsuccessful interior attack. "In many plastics, fire will burrow into the center and actually burn from inside out...once this gets going, water really doesn't do much except create steam and put a lot of water on the floor."

The interior attack was abandoned after about 10 minutes. The subsequent exterior attack was eventually (8-10 hours later) able, with the help of the fire wall, to contain the fire in the front part of the single-story area.

INCIDENT ACCOUNT #22

FIRE BUG

The incident took place about one month prior to the interview and is of interest because of the amount of stress endured during the search and rescue of children. The FGC was at another fire when this alarm was called and had to call dispatch to put himself on the run. A large crowd was on the scene when he arrived which caused crowd control problems, and an hysterical 300 lb. woman wanted to gain access to the building, disrupting firefighters operations.

Chief D had gone on a run to another location when this incident was called in. This first run was stressful because the first units traveling to the alarm with the Chief were blocked by a train at a railroad crossing. It was after 2300 hours and they could see the flames of the burning building lighting the sky from their position, but they could not get past the train. The Chief had to tell the dispatcher to call other units to the scene, while the first alerted units set out on an alternate path which took them several miles to negotiate. After finally arriving, the Chief saw that fire was being contained by the substitute companies. Chief D then saw the District Chief head to his squad car and, listening to the fireground communication radio channel, heard him say he was leaving for another alarm location on a street inside Chief D's district. Chief D then called the dispatcher to say he would assume responsibility for this second incident and was leaving to attend to it. This was approximately 2320 hours.

Chief D arrived at the location in two to three minutes. He saw a long 2-story apartment complex with large amounts of flame and smoke coming from a 2nd floor apartment. This building had had previous fires (started by a child playing with matches), so the Chief knew the occupancy and general layout of the building.

The building was located on a dead end street, which would make positioning equipment difficult. An apartment complex was across the street on one side and another one was behind the building on fire. A parking lot and turnaround circle blocked the end of the street, with the other end opening on to the only access street. The Chief's previous experience with the building had informed him that part of the building was unoccupied, but the evacuation of the remaining sections could necessitate a second alarm, a possibility he had considered likely after his first visual contact.

A large crowd had gathered outside, vocalizing the need for the rescue of children still trapped on the 2nd floor. One engine and one paramedic crew were already on the scene. The lieutenant on the engine squad had had to make a strategic decision to split his three man crew, taking one firefighter inside with him to search and rescue the burning apartment on the 2nd floor. A new and inexperienced recruit was left to take a hose by himself into the building, with the pump operator monitoring the engine on the street. This was not an ideal situation. Standard operating procedure was to have

firefighters work in pairs. The Chief had made his way to the building in time to see the lieutenant and a firefighter going up the stairway of the building.

Chief D could see that the fire was located specifically in one apartment that showed a large amount of flames and smoke. The surrounding apartments were not yet showing flames or much smoke to indicate a spreading fire. Smoke was, however, starting to come out the attic vents of the eaves of the building, possibly indicating that the fire might be spreading to the attic.

An hysterical woman suddenly materialized and attempted to enter the building just as the lieutenant and the other firefighter were coming back out, bearing the unmoving forms of three children. Chief D had to restrain ("wrestled") the woman to allow these men room to get out of the building. The children were laid on the grass; one child, a two year old, began to breath on its own immediately, the others were being worked on by the paramedics. The Chief immediately called for another paramedic team; only a minute or two had elapsed since he got on the scene. The two children not breathing required immediate CPR and the one medic crew could not attend to both. The Chief made another call for a paramedic squad, less than a minute after his first call. The obese woman was still attempting to enter the building.

The fire continued to burn; the only attempts directly at containment were from the rookie firefighter. There was an extreme amount of heat being emitted and large amounts of smoke in the one burning apartment. Search and rescue operations were being conducted so fire containment was now the issue. Chief D elected to specifically request additional equipment rather than call for a second alarm to this site. He radioed for two more engines, a ladder truck, and an additional District Chief. The call was made about only four minutes after the previous medic squad alerts; roughly under ten minutes had elapsed since his arrival. (The Chief had also made a request for police to be sent for crowd control. Sometime during this time - perhaps at the same time as the second medic squad call). Chief D began to relax a little, the first engine and ladder crews starting to knock the fire down, and knowing additional equipment and paramedics were on their way.

Placing the equipment was a concern because of how congested the front of the building was with an engine directly outside, rescue operations, and the crowd of people - all on a dead end street. Equipment would not be able to be maneuvered close to the building. This was particularly weighting on how ventilation operations were to be carried out. Many of the second floor windows were already open and some citizen had kicked in the front doors. These actions had served to oxygenate the fire. If a ladder truck could have been put closer to the building, an aerial ladder would have been ordered to the roof and firefighters directed to chop a hole to redirect the smoke and possible fire in the attic. Instead, ladder crews had to carry their equipment into the building, stepping over and through the engine crews' equipment and operations. Their orders were to rip down the dry wall ceilings of the critical apartments to ventilate and investigate the attic.

Portable lights were brought into the building to aid in this action. A short time after they had been put to use, the burnt body of a twelve year old was found. He had probably been dead before the crews had arrived, inside a room of the fiercely burning second floor apartment. The other three children were also found in this apartment, but the fourth was not found in the grouping of the other three.

The additional District Chief had by this time arrived and Chief D directed him to assume responsibility for the back of the building. Chief D or his aide had not had time to perform this reconnaissance because of the pressing necessity of search and rescue. The length of the building also was a barrier to a quick look. Front operations were retained under Chief D's purvey.

The back was found in no immediate danger and the second Chief directed his crews to complete the evacuation of the building. It was later known that the fire had run into the built-in firewall of the structure which acted to contain the blaze from spreading. Far smaller property damage was sustained because of this and the blocking of aerial ladder roof ventilation actions. The fire was contained and extinguished without further incident.

Afterwards the fire was found to be so hot that several firefighters had sustained some light burn injuries on their knees, where their boots stopped below and their fire coats slightly above.

INCIDENT ACCOUNT #23

CHEMICAL PLANT FIRE

The incident took place at a manufacturing plant producing/packaging paint thinner and related solvents. The high volatility and explosive nature of the products made this fire a high risk event to both firefighters and property. Because of this danger, two men refused to take part in operations. A second potentially explosive situation developed from the firefighting foam operations performed at the alarm site: foam and flammable liquid runoff drained into the basement of an adjacent building and was not found for sometime after a few units were released from the scene.

A box alarm came in at about 1530 hours. Chief G heard the dispatcher give the alarm and recognized the location as the scene of a chemical fire about ten years earlier. When the first units arrived and said they had a working fire, the chief left for the site before being officially called. ("Because of that fire ten years ago, I knew it would be more than a one alarm fire. You see, factories aren't real neat areas.. there's tanks and drums scattered in different areas...")

On his way to the scene, he heard the dispatcher activate the Hazardous Materials Unit, of which Chief G was in charge. The dispatcher then began to relay windspeed and velocity information, followed sometime after by "chem-trac" file information, which contained the last fire inspection of the building, e.g., type and location of stored chemicals, drains, exits, etc. The Chief also noted specific cues about the fire on his way there. He mentioned particularly the volume of the smoke and its color, as well as its location when he got there. White smoke would indicate that the firefighters were hitting the fire close to the core ("...that white steam helps you know where the men are positioned and where their lines are"). In response to a query on how much planning he did on the way to the scene, the Chief indicated that he actually didn't make any specific plans and the few made regarded the importance of protecting the flammable/toxic material holding tanks.

At about 1540 hours, the Hazardous Materials Unit arrived on the scene. By this time the Chief had sized up the scene and identified and exposures to protect from being enveloped by the blaze. These were the west side (to protect adjacent buildings), the east side (to protect the storage tankyard), and the roof. He recognized the roof as being made of composite material that included tar, the ignition of which could spread the fire to adjacent buildings, or other areas in the same structure. The first arriving units were already defending the first two exposures, but the Chief had to give the explicit order for line to be laid directed at the roof by the next arriving unit.

His next concern was to set up foam operations and put them on standby until the tanks exposed to the heat were cooled down. Then exposed tanks had to be cooled down with water because they were potentially explosive. The fire itself could not be fought with the foam operations until the water operations ceased, because water

renders the foam inoperative. When to initiate foam operations was conditional on the relative temperature of the tanks. The Chief mentioned several possible cues that helped him get an indication of when the tanks were 'cool enough,' e.g., if heat waves were still rising from the tanks, if the tanks were still swollen by heat expansion, the sound of the water from the hoses hitting the sides of the tanks, actually feeling the larger tanks with one's hand. ("I know when the tanks are cool enough but I couldn't tell you how to judge it. It's just like cooking..how do you tell when something's done?"

At approximately 1610 hours, the tanks were judged to be cool enough for foam operations to begin. The fire was successfully controlled within 40 minutes of this operation. However, routine explosion meter readings (indicates ratio of flammable gas to air) taken during salvage and mop-up at approximately 1730 hours, revealed a potentially explosive situation in the basement of the adjoining building -- hazardous runoff, comprised of the flammable liquids and foam had been draining undetected into the basement. The Chief considered this situation to have resulted from insufficient monitoring of fluid drainage. Because of the late discovery of this situation, equipment and men had to be recalled, and available personnel resulted. Operations to clear the basement continued for another hour, and were successfully completed.

INCIDENT ACCOUNT #24

APARTMENT EVACUATION

This fire occurred within the past year. It posed a challenge because of the evacuation efforts and the problems posed by the elderly citizen evacuees involved. The incident took place in a brick/concrete 5 or 6 story apartment complex for senior citizens. The danger to the occupants was not from the fire spreading, but from the injuries possible from smoke and fume inhalation. Coordinating evacuation activities and providing creature comforts to the evacuees were the unique demands made of the FGC.

Chief W was sitting in the station house when his house district chief reported seeing a fire in an apartment building across from the station. The Chief went out to investigate and saw flames coming out of a 4th floor window of a building he knew to be a senior-citizen-only structure. He returned to the station, notified the dispatcher he would be out of the firehouse to attend to this incident, and proceeded to the scene. He arrived before his district chief and the alerted fire companies, at approximately 0930 hours. Aware that the building was a concrete and brick structure, the Chief appraised the danger as being casualties due to smoke inhalation, and not the actual spread of the fire. "You let fire get in one room it very seldom will ever get out, until a door's open. You open a door into that room then fire'll escape and get into the ceiling of the hallway. There's so much cement there, usually it'll burn just right in that one room."

The normal procedure in apartment fires is to evacuate 1 floor below and 2 floors above the fire, but the Chief only considered evacuating the entire building in special deference to the possibly fragile condition of the inhabitants in their advanced years. The first company arrived and began to lay two lines to the standpipe emergency water supply system provided in the building. The immediate concern was to get a water supply to the top floors as soon as possible. In the meantime, the Chief called for the Emergency Medical Service (EMS) Director to care for the possible casualties and also aid in evacuation.

The fire was now reaching up the side of the building and threatening to leap a floor to another apartment. Chief W assigned a truck company and other non-involved firefighting personnel to the evacuation effort. He designated a staging area for evacuation efforts and initial care area for the evacuees. Firefighters had now reached the apartment on fire and the act of opening the door caused a suction which helped pull the fire back into that apartment and away from escaping to the next floor. The fire was then put out, approximately twenty minutes from the time of the Chief's arrival. The danger of inhalation injuries still remained, however, and the Chief was in charge of the evacuation team which had now swelled to include seven ambulances, ten police squad cars, the EMS, and a civilian auxilliary group ("similar to the Salvation Army"), plus three ladder companies and several engine company personnel. The Chief mentioned that special efforts were made to keep the evacuees reassured and relatively calm because "...they're alot like children,

they gotta be told they're o.k., because panic could set in real quick." Evacuation efforts continued until the building was emptied. All residents had not returned to their rooms until about 1800 hours.

INCIDENT ACCOUNT #25

BACKDRAFT #2

This incident occurred over 25 years ago. It took place in a blighted, run-down area where there was a danger of fire spreading to adjacent wooden apartment structures near the initial 3-story wooden apartment structure fire spot. The Chief was a lieutenant then, and noticed the rare phenomenon of a "backdraft" of smoke and gases from the fire, but could not evacuate his men in time to insure his men's safety. (Backdraft: A buildup of gaseous products of combustion that cannot escape and can potentially explode to vent the pressure of its accumulation. This is an extremely rare and dangerous event, one not likely to be seen more than once, if that, during a career.

A call came in about 1800 hours that gave an alarm location in a blighted area of the city with many wooden structures and big 3-story houses that were chopped into apartments, all close together. As the first company at the scene, the then Lt. B led his men inside after the pre-assigned men hooked up to the nearest fire hydrant. Although on first arrival the lieutenant could see smoke on the 2nd floor, no flames could be discerned and so the initial plan was to go to the 2nd floor to find the source of the smoke.

The smoke was thick on the 2nd floor, billowing both yellow-gray and black. ("...a sickly yellow-gray smoke you get from mattresses and chairs," plus "that black smoke from tar and plastics.") Lt. B ordered his men to stay low and keep the lines going. He could see that the smoke extended down the hallway and there were many doorways leading off the main passageway which made finding the combustion source more time consuming. About ten minutes into the hallway operations, the Lieutenant saw the smoke lifting at the end of the hall and flames. ("...smoke starts raising up and the hallway became real clear, then it started coming back down again.") Recognizing this phenomenon as the "backdraft" process, he yelled to his men to get out, but did not get them all safely evacuated before the hallway exploded. Some men were blown into the apartments leading off the hallway. One firefighter was blown through a window but landed on the 2nd story's small outside roof. Fortunately, no one was seriously hurt.

INCIDENT ACCOUNT #26

POLYURETHANE FACTORY FIRE

The toxicity of the burning smoke in this fire influenced all tactics and procedures and illustrated the importance of having this information prior to the incident (know your enemy).

The alarm was received just after midnight on Sonitrol, an automatic alarm system. This is called a "waterflow alarm" because it is triggered automatically when the fire sprinkler system is set off. The speed with which the call was received was considered a factor in the successful control of this fire. However, the address given in the alarm was incorrect. The company arrived at the designated address within 2-3 minutes of the alarm and radioed their report "nothing showing." The FGC spotted smoke about a block away and proceeded to the scene, arriving in less than one minute.

The location was immediately recognized as a factory which, from pre-fire planning, was known to be insulated with polyurethane. Burning polyurethane creates highly toxic smoke and the FGC, Chief W, felt that this factor was the key in his strategy for fighting the fire. Whereas normal procedure would be to initiate search and rescue and investigate the possibility of an inside attack, the smoke toxicity made going inside virtually impossible. Although Chief W indicated that had there been any signs of life, greater risks would have been taken. The late hour and the absence of cars or lights inside the building allowed Chief W to decide not to initiate search and rescue. He made this decision almost immediately and with confidence. However, later information revealed that the fire had indeed been started by someone using a space heater inside the building. The individual had to escape the fire and his car was still near the scene, almost turned over as he had tried to drive away and hit a wall. This individual had made an alarm call to the fire department after the Sonitrol alarm had been received. This information was not available to Chief W. There is a question as to whether knowledge of this individual might have delayed the decision not to search and rescue until after he was questioned. Probably the known risk of the smoke danger made Chief W less sensitive to the possibility of life in the building than he might otherwise have been.

Chief W ordered a second alarm almost immediately upon arriving at the scene, which is standard procedure in a working fire of this nature. He felt that this decision was made automatically and he never really considered the alternative of not calling an alarm. "First you call the alarm, then you can sort of figure out what you're going to do with them when they arrive. As it turned out, I really needed the extra manpower for the external attack and I especially needed help with keeping the men's air tanks filled." Because of the smoke toxicity, all men had to suit-up (put on masks with air and wear protective clothing).

Two firefighters are designated to be suited at all times. Chief W took these two men to investigate the west side of the building

approximately two minutes after arriving at the scene. The decision was made to hit the fire where it was burning on the west side. The complete combustion here made for less smoke and therefore less danger. Thus, this decision appears to have been made as an immediate recognition of a procedural rule. Since he was not going to try to send men into the building to push the fire out, there was no attempt to consider other options. He saw an opportunity point, and he reacted. He had no need to gather additional information, and the attempt to do so would have caused pointless delays. (He also had seen nothing that suggested that other building sites were of equal or greater value.)

Almost immediately, the firefighters began to tear out the wall at the point of attack and discovered a propane cylinder which was at risk of exploding if it was not kept cool. It was very fortunate, therefore, that that tank was discovered, since no information concerning its presence was available. The tearing out of this wall was not the result of direct command, but simply firefighters following their own knowledge of what needs to be done.

A third alarm was called within a minute of beginning the attack on the fire, standard operating procedure given the involvement of the units at the scene. This alarm ensured a fill-in pumper would be available, although in this case it was not needed.

Approximately 15 minutes into the fire a ladder was set up to hit the fire from the roof. This was done through a natural process of bringing equipment into play, rather than through a specific command. This is the way such fires are fought.

This was judged to be a very successful operation and was reported to be contained within 20-25 minutes of alarm call with no injuries and with minimal property loss given the extent and ferocity of fire. Equipment was judged to be more than adequate, with manpower falling somewhat short of optimal.

INCIDENT ACCOUNT #27

FATAL HOUSE FIRE

The residential fire took place about 15 years prior to the interview, and was recounted because of the drama surrounding the attempted rescue of 2 children, both of whom died. Because fire size-up had to be deferred until rescue efforts were complete, and because of the trauma related to the childrens' deaths, fire control efforts suffered. This was costly because the fire was advancing in unsuspected avenues, in an unfamiliar fashion.

It was a January night, about 0038 hours, when the call came in on the fire phone. The location was a residential area. Chief DW was off duty and was riding with Chief TW. When they arrived, seconds after an engine that was already on the scene, little of the fire was visible from the front of a large 2-story house where they parked although a large amount of smoke could be seen. A citizen grabbed Chief DW and told him two children were inside the house. The citizen was recognized as the Superintendent of Schools, and the report was accepted without doubt. Chief TW put on his protective mask and gear, grabbed the two masked firefighters from the engine squad and made his way to the bedroom window pointed out by the citizen. Chief TW tried to break the window with his helmet, but the plexiglass window would not break. Immediately going to the next window, Chief TW broke the glass on the first effort.

Peering inside they could see a TV still on and a bed in the room, but the dense smoke prevented any further view much beyond three feet. A masked firefighter was helped through the window. The second masked firefighter was just entering the window when the first man in shouted he had found a child. The child was handed out the window, limp and presumed dead, as another child was found in the same condition in the room. The second body was handed out at 0049 hours. Thus, although rescue went well, the fact that the children were not found alive was devastating to the firefighters on the scene.

In the meantime, the engine company that arrived shortly before the Chief's car had been laying a hose to the front door. Advance into the house was slowed because the only masked firefighters had been diverted to rescue operations by Chief TW. The fire had been sectorized into two operations, one search and rescue, the other fire control/property control. Both chiefs were intent on rescue so the lieutenant on the engine squad assumed the acting command of firefighting operations. Four or five firefighters were sent into the residence, crawling on the floor (to avoid the smoke) dragging a hose. They made their way to the family room and kitchen area at the back of the building.

Chief DW had seen the two dead children and had left Chief TW's side to go around to the back of the building to begin his size-up of the fire control efforts. He got to the family room window, saw his son among the firefighters inside the house, and called to him to find out whether the fire had been located. It was reported that nothing but heavy smoke had been encountered to that point. The firefighters

inside continued to search and the ladder crews continued to break out windows to insure ventilation.

Chief TW made a second alarm call to bring the District Chief and an Assistant Chief to the scene when he knew for certain that the one child was dead (the other was pronounced DOA at the hospital). Shortly after this call, flames began burning through the roof of the house. This was an additional clue that this was an unusual fire because a well-experienced and trusted firefighter had gone to the 2nd floor minutes before and reported all clear. This event gave the only access to flames in the house to that point.

Several firefighters and the Chiefs had experienced a letdown after finding the children and firefighting operations were less keenly motivated because of it. The fire had not been localized and it had become apparent when the roof burned through that the house too could well be already lost. The District Chief and the Assistant Chief had then arrived, about five minutes after being alerted.

A fire safety officer had come along with them. The Assistant Chief began to give his own operation orders, buttonholing some firefighters from a ladder crew and directing them to the roof to ventilate. In Chief TW's opinion, this was a dangerous action because the fire had not been located yet and the roof might already be subject to fire damage.

The fire source was not located until about an hour after the first unit's arrival.

Several points about this fire were quite unusual to the Chiefs. First, no information was given about whether the father and the mother were inside. No rescue operations were therefore directed to search for them. The father was later found dead inside the garage, apparently after going to investigate flame or smoke. The rescue squad that was to arrive with the companies went instead to a neighboring house, where the burn injuries of the fleeing mother and son needed to be treated. This diverted some manpower and mask equipment from the fire scene, thereby further weakening the first attack on the fire itself. Another point was the unusual construction of the house itself that actually fed the fire and kept it from view. A true size-up was never conducted.

INCIDENT ACCOUNT #28

WAREHOUSE FIRE

The incident took place three years previous to the interview. It was a quickly advancing fire that was aided by the oil-soaked floors of the 100 year old former machine shop building where it took place. The strategy almost immediately turned to defensive operations of preventing expansion instead of the initial attempts at hitting the fire directly. This was frustrating to the firefighters who unexpectedly received some help in their operations from the usually serious complication of the roof falling in.

A police call came at 0056 hours reporting that smoke was seen in the area of an old wooden 2-story warehouse and sales building complex. A pre-fire plan existed on this structure and the fire company had bought some equipment there, so familiarity with the building was good. The building was also known to have been a machine shop in former years and had oil-soaked floors as a result.

Chief W had responded to the fire phone call and was on his way to the scene before the alarm was given. There had been a recent problem with prank alarms in this area so the Chief took a different route to the location of the alarm than the rest of the fire equipment in order to perhaps catch a fleeing prankster. It took him 3 minutes to arrive at the scene, but this route gave him a view of the building which included visible flames, a view the other arriving crews were not privy to. The fire was coming out of the 2nd floor windows on the south end of the building. The radios in standard issue were of poor quality then, so the other arriving companies may not have been directly informed of the site of the fire but possibly picked up the alert from dispatcher broadcasts.

The first arriving engines came to the east of the building and began to lay lines from a known working hydrant a block east of the building. Chief W and platoon Chief B had been working together for many years and these experiences together evolved an understanding which gave platoon Chief B great latitude in his actions with his crew. Platoon Chief B directed the east side operations on his own initiative and set his investigation point to be the large barn doors visible on the east side. The firefighters of this crew went to open these doors but fire damage had already weakened them and the attempt to open them caused them to separate from the building. These actions revealed that the 1st floor was well involved. Platoon Chief B had not left the running boards of the first arriving engine in order to direct by truck radio the other arriving equipment to the most appropriate stations when the extent of involvement on the 1st floor gave him the realization that a second alarm would be necessary.

The standard procedure was to have Company #3 come in to cover the fire station which Chief W and Platoon Chief B had vacated to make the run. Platoon Chief B called the dispatcher to divert #3 to the scene, which then would activate Company #6 to take over #3's support role. On the way to the scene, however, Company #3 had to respond to a box alarm in their area, so Platoon Chief B directed Company #6 to

proceed to the scene. The box alarm Company #3 had gone to investigate was pulled to alert the fire company of the same warehouse fire that was now in progress. This delay caused #3 to arrive shortly after #6 had made their way to the scene. Platoon Chief B continued the direct placement of the equipment as it arrived.

Since this building complex was well known to the Chief and other officers at the scene, the identification of exposures was made almost automatically. A lumberyard on the north adjacent block, a church across the street to the east, and a liquid gas company on the south adjacent block were readily apparent as necessary to be defended. Chief W was in position on the southeast to make the more difficult assessment of how to deploy the fire companies at the scene to protect the west side of the complex. Two newer 1-story buildings existed on this side of the building running north-south, one behind the other. These buildings contained the sales outlets for the warehouse now on fire. Talking to the platoon chief within five minutes after his arrival and after the door operations, Chief W came to the conclusion that the old 2-story building would most likely be unsaveable. He had seen the 2nd floor involved in the south and was now aware that much of the 1st floor was involved. The strategy then became to try to contain the fire to the older building, a defensive objective because the heat and extent of the fire prevented any safe direct attacks.

The plywood covers over the 1st floor windows were now burning through. "Plywood burns slow," the Chief knew, and "from the angles we had to fight the fire, there just wasn't a way for us to get enough water on the fire to absorb the heat and lower the temperature, especially with the roof on." Attempts to ventilate the 1st floor proved how extensive the fire had become. Several firefighters had been sent to remove the plywood covering from a 1st floor window approximately 100 feet in front of the paint where Chief W had seen flames and had found that the fire had eaten its way practically through the wood sheet.

A ladder pipe had been ordered to set up east of the building and a snorkel station southwest to aim their streams of water down on the sides and the roof. Chief W wanted two 2 1/2" lines on the west for better mobility in response to a changing front, but was overruled by the Chief arriving with the second alarm, who instead set up a stationary snorkel operation there. Little effect on the fire was shown. The oil-soaked floors of the old building were feeding the fire and making it resistant to the firefighting operations. Because of this, a third alarm was called for additional manpower and equipment.

Twenty minutes after the Chief W's arrival, the roof was burning through. The heat was intensifying. The roof of the church about 200 feet east of the warehouse began to steam some minutes later. Another engine was ordered to keep the church roof wet. Company #4, which was to provide the support service #6 was to have assumed, had by now been diverted to the scene and set up operations on the west and southwest sides, to help protect the sales outlet buildings. The fire continued unabated.

Two squads of men attempted to go through the sales outlet structures to keep the warehouse fire from gaining ground in this direction. The intense heat prevented much advancement. All companies were in place now, about a half-hour from Chief W's arrival. Holding actions were continued until the roof unexpectedly caved in.

The roof collapse occurred about 45 minutes into the operations, and was the most fortunate event in the incident. By falling straight down, and taking the 2nd floor with it, the roof actually snuffed out large sections of the fire. The open structure was now ventilating itself and provided a much needed direct attack front for the firefighting operations. The Chief had to direct his men away from the north and south walls of the building where the unsupported apexes now posed the danger of falling down away from the structure. The operations, however, now had offensive opportunities and the new shift in focus was successful in containing the blaze 15 minutes after the roof collapse.

The warehouse was a complete loss and one of the side sales buildings sustained heavy damages. The other sales structure was saved. Mopping-up operations continued throughout the night. The last units returned to service about 0700 hrs.

INCIDENT SUMMARY #29

NAKED MAN FIRE

In the winter of 1985, firefighters were called to a downtown building by a telephone report of a fire. Preknowledge of the area, but not the building in question, aided firefighters in rescuing the residents of the apartments located in the upper floors of the building.

Just past midnight firefighters were summoned to an address two blocks from the central fire station. Within a minute the first engine and the Chief B had arrived. Following normal procedure, the engine parked in front of the building while the Chief drove to the rear. The officer in charge of the engine crew immediately ordered his masked firefighters to enter the building.

Chief B covering the rear of the building noticed smoke in the front of the building as he drove around the corner. Once in the rear of the building the Chief climbed the steps to the 2nd floor. Flames were visible underneath a door there. Knowing that the east side engine was on their way to, he quickly radioed to them to come to the rear of the building rather than the front of the building.

Within a minute the Chief was aware of an elderly resident on the fire escape on the 3rd floor. He yelled to her to remain where she was until he could get someone to help her down. While he turned his back and walked toward the platoon chief, the woman began to descend the vertical fire escape alone. The platoon chief quickly climbed the escape to assist her the rest of the way down.

After the arrival of the east side company, the chief went to the front of the building. There he witnessed ff removing a naked male from the roof of the building. Within 15 minutes, the fire was contained and according to standard procedure, the chief had called the arson investigator to determine the cause of the blaze.

INCIDENT ACCOUNT #30

PUMPING STATION I

On Christmas night 1983, Captain F was taking his turn substituting for the regular chief. After dinner, a young man ran into the fire station declaring that there was a "big fire on the road." From the fire station, "we saw this tremendous fire in the sky." Immediately the firefighters put on their equipment, got into their units and notified the dispatcher to phone the volunteers. At 1915 hours, the Capt. and his men proceeded directly to the scene, stopping just north of one fire.

On first observation, Capt. F noticed that most of the big power lines of the tank were down and burning. The telephone poles were also on fire. He could not determine how many tanks were involved, at least two it seemed.

Not far from them, still north of the fire, there was the pump station where they saw a couple of men and a power truck. The men claimed that there was still electricity coming from the north and south, but that they could not cut it for a while for reasons that were not clearly communicated. Capt. F observed fire outside one ditch (which enclosed each tank) where the oil had spilled over. In preparation for making a size-up the situation, the Capt. and his division proceeded south. But they had only proceeded a short way when he noticed oil in a ditch. Aware that a "fierce" wind was blowing toward them from the southwest, Capt. F feared that it might blow the fire along the oil in the ditch at any minute. Therefore, they retreated, circled the pipeline field through a road cutting through the Army tank plant to the west and arrived at a vantage point south of the fire. Here he encountered the chief of another fire department who had stopped there on his way home. It seemed that three tanks were involved in one fire, on the west side of the highway.

Suddenly, the middle tank ruptured and an infernal wave of crude oil could be seen riding over the highway where it quickly engulfed tank 91. Then a man from a pipeline company came by, commenting: "Boy, I hope that fire doesn't come south any farther. There's a twenty inch propane line goes through here!" Fortunately, thought Capt. F the wind was not blowing south - not at the moment, at any rate.

Capt. F knew that foam is needed to put out oil fires. They have to be smothered with a blanket of foam. He called a nearby oil company who he believed had more foam than anyone else in the vicinity. They agreed to send him a truck with 1000 gallons, but they had to maintain a reserve supply for themselves, just in case the fire broke out over there.

The perception of the wave of fire crossing the highway also made the Captain think thatt "maybe we better move these people out of the immediate area." There were residences to the north of B. Road (including Captain's own house) and to the south on R. Road. He had the rescue squad pick up his wife and take her to the fire station,

where she would remain and help distribute donated food to weary firemen. He ordered the police to notify inhabitants of these areas to go and stay with relatives or friends for a few days. (Those few individuals without options were given free lodging in a local hotel.)

Although he did not know for sure that the fire would eventually reach their homes, he reasoned that what happened to the ruptured tank could happen to another tank, and the enflamed crude could spread in any direction, at any minute, without any means to stop it. Asked if he imagined all 20 tanks in the field bursting, he replied, "We talked about it. Where's it gonna stop? We might lose the whole thing (the pipeline company), even the nearby plant." Officials at the latter installation feared this also. They soon closed their gates and took security precautions.

The Captain returned shortly thereafter to the northern edge of the field. He observed the intent to which one fire had spread from the ruptured tank beyond it's dike to the northwest. They were alarmed by one discovery in particular. The oil was following gravity northward - "creepin' like a little monster" - in a ditch that beyond B. Road veers to the west under a railroad track (on which there were cars), right through the large chemical plant. Around this time he called the neighboring fire departments of C., H., and P. "I thought now if that oil gets in the chemical plant and that ditch fires, then I got a problem."

He then ordered a couple of volunteers to run with it along the ditch to determine where the oil had reached. They found the end of it just 30 feet from the railroad. One road superintendent for the township (was also a volunteer), happened to have a truck load of salt and gravel. Capt F. ordered him to bring the truck so they could seal off the ditch to prevent the oil from spreading.

"They kept haulin' and haulin'. They diked that thing up." By 2010 hours, the drainage ditch was blocked.

When he returned south a foam truck from the oil company had arrived. Then they began to put out the fire that had spread in the field outside the dike. This helped them protect the pump station which they had wanted to use both as the command post, and as a place of refuge from the intense cold.

After putting out the field fire, the State Fire Marshall arrived; the command post was set up. Inside the pump station were the dials which recorded how much oil was in the affected tanks. (The north most tank on the west side was 1/2 full. The south most tank nearly empty, and tank 91 on the east side was full (96,000 barrels).

Around this time, he came to be aware that Captain R was on the scene. Capt. R and Chief C were planning to put out an oil fire that had remained burning around the rim of tank 91 after the seal had burnt off earlier. In preparation for this assault, F asked Standard Oil for another load of foam. They agreed to send about 800 gallons. Captain R was eventually able to make the attempt, but

it did not succeed (see R Account). According to F, "The wind was breakin' up the foam" before it could form a complete blanket over the fire, although at one point, almost two thirds of the fire seemed put out. He agreed with the strategy used even though it proved unsuccessful. As emphasized in Captain R's account, these decisions were not made by one man alone. There was alot of discussion and consultation. According to F, "Nobody disagreed on anything...There'd be a suggestion, we'd mull on it...let's give it a try."

When asked if another method could have been used to extinguish tank 91, Capt. F referred to two previous cases of rim fires years ago at an oil company. With some trepidation, he (with his men), had climbed up a ladder adjacent to one tank to foam it down. The other was handled similarly by the crew at the oil company. However, he commented "I ain't as careless as I was." In the case of tank 91, the conditions of both the tank and the weather led the decision makers to the conculsion that it would be too dangerous for any of their men to climb up. (The newer tanks are outfitted with automatic foam distributors, to prevent the need for firemen to take such risks).

They were not willing to let it burn since unlike the three other tanks, No. 91 was full, and if it should heat up enough to rupture, the loss of that much oil would be around \$200,000 and the possible impact on the pipeline could be considerable. He cited cases of two tank fires started years ago by lightening. At that time, the price of crude oil was low enough that it was decided to let them just burn out. But now, he added "You'll have men go up (the tank) for the cost."

When asked if they could have pumped the oil out of either tank 91 or the tank across the highway, he replied that they did not know if the pumping lines were still intact. They did not want the oil to be pumped out through a leak into the fields where the fire might spread. Moreover, the fact that tank 91 was full was a temporary advantage: it would take much longer to heat up than the other tanks had, and therefore would take longer to boil over or rupture.

As it would turn out, others would make the attempt to climb up tank 91 - The "experts" from an oil company from T. (who failed), and the men from B&C Comapny (who succeeded in extinguishing the blaze).

INCIDENT ACCOUNT #31

PUMPING STATION 11

Captain R became aware of the pipeline fire while at home. After watching the sky "lit up" by the blaze, he tuned in his scanner to learn what was happening. It was Christmas eve and he would not be on duty until 0700, the next morning. However, he felt obliged to go to the site of the fire that night. By 2100 hours he arrived at the fireground. At the north end of the major highway, facing south, he could see the highway between tank 91 to the east and the 3 tanks to the west was full of fire and the tank on the side enveloped in flames. He noticed power lines were down, and electricity would need to be cut before an advance could be made in this area.

Meanwhile, he focused on a branch of the fire which had been travelling northwest along a ditch away from the fireground toward railroad cars that were located on the perimeter of the neighboring chemical plant. Captain F took charge of putting this fire out, which involved the construction of the dike and the application of foam. Captain R, unaware that Captain F had already ordered a foam application, commanded the pump operator to foam the ditch.

In this interview, Captain R pointed out that the precise decisions reached concerning foam application followed considerable amount of discussion of options between the officers and other firemen. Communication was not easy since it was cold and dark, and most men, if not all, were wearing ski masks due to the cold.

Captain F then asked Captain R if he could be of assistance. Captain F replied that he might go home to get a night's sleep so as to be fresh for duty the next morning, but R elected to stay. Reasons for this included his sense of duty, the irresistible challenge of this fire, the realization that every firefighter would be needed, and certain protective feelings he had for Captain F who was soon due to retire from the department. Captain F accepted R's decision to stay and designated him senior officer in charge in the field.

Captain R then proceeded to begin making a size-up of the fire. Communications had not been adequately established between the various companies involved. No one had enough information to form a strategy of attack. On the faces of a number of men, even some of the most able, he saw "blank stares". No one had seen such a huge fire before. It was 40 degrees below zero that night and with a strong wind blowing from the southwest.

With the Chief of a neighboring department, Captain R took a trip around the fire ground. They stopped at a position just north of the fire. During the next few hours, continual discussions took place on how the fire might be divided up in order to extinguish it in steps. It would be impossible to treat it otherwise.

The first step involved getting the electricity to the area

turned off. No attempt could be made to enter into a position to fight the blaze due to the danger downed power lines. Captain R did not have the radio frequency to contact the power company directly, so he relayed the message through another department on the scene. Unfortunately, after several exchanges of messages the order was not carried out. Captain R managed to speak with the company directly and ordered them to remove the lines and shut off the electricity immediately. They did not comply right away.

While they waited for the power company to comply with the request, time was spent deliberating over how to attack the fire. The main concern was "what to do to split this thing." According to Captain R, the decision was ultimately arrived at collectively. He expressed this unusual process in several ways. It was "one of those things: 'I get an idea and everybody says, yea that's what we'll do and you go with it'." Later he remarked:

"I really hesitate to say whose decisions they were.

All these matters were handled because there were so many conferences going on. As it turned out in the end, everyone made a point of how this was conducted. There was no king pin. There was no king pin department, but it worked out."

Though he admitted to having "most of the final decisions", he qualified it by adding, "but boy did I rely on them to help me." Searching for a more appropriate way to characterize it, he concluded, "decisions came from a field command office (meaning the group of chiefs from the collaborating departments)."

Concerning what plan of action to adopt, "It evolved to a point where we...said let's stop this fire on the east side by splitting it into two at the highway. We'll worry about the origination point (to the west) after we get this thing contained." Thus, when the power would be turned off they would aim to extinguish the rim fire on tank 91. The seal of this tank had been burnt off and the oil was burning all around the circumference of the floating roof.

They chose to split the fire along the north-south highway since it was felt to be the best point of access to the fire. Although one normally directs an attack against the seat of the fire, in this case, they did not choose this option. One reason was that they were aware that they had nowhere near the resources to extinguish the raging origination point. Secondly, "by letting it burn it might just be taking care of itself." The most important factor on their minds was the danger of the fire spreading. Conceivably tank 91 could rupture, as did the origination tank. Nightmarish visions "danced through their minds - the fire could spread to the 16 other tanks in the field, perhaps beyond to a neighboring plant and the huge Chemical Co....". "We don't know what weaknesses that tank 91 has been put to. It had been fully engulfed in flames earlier on when the fire had spread to it from the west. We had one tank go down, why not this one?" The question was how to put out the rim fire?

They began to inventory their needs and the resources available through the Mutual Aid Agreement. A big ladder truck from city B,

and foam from S Oil were needed. Water would have to be tanked in since there were no fire hydrants on the pipeline site. Consultation would involve specialists from the Pipeline Co., Capt. F and the chiefs from other fire companies.

Toward midnight, after the highway fire finally burned itself out, the power lines were finally shut down. The chance would come now to fight the fire in tank 91. From previous experience it was felt that if sufficient foam could be applied to the rim, the fire could be extinguished. But in addition to the problem of securing foam and water, there was the more thorny question of how actually to get the foam onto the fire. It was freezing-cold, dark and windy. Where would they position the ladder truck? Should firemen climb up a ladder to the rim with a hose? Ordinarily one should try to get the truck as close as possible to the fire, but in this case, dikes prevented easy access to the tanks and the field around had dangerous ravines.

Captain R drove around tank 91 to examine the quality of the terrain. It was uneven, making travel across it slow and hazardous. It was decided not to take the ladder truck off of the road beyond the dikes. It was feared that the \$400,000 truck could perhaps break an axle or, worse, become easily trapped and burned if the tank should boil over.

For a similar reason they did not elect to send firemen up a ladder to the rim, even though this procedure had been used with success in previous rim fires. Although there was some difference of opinion on this matter, the idea prevailed that it was too dangerous a situation to send a man up the tank. Even though such an effort might save several million dollars in crude oil, the commanders did not feel that it would be worth the value of the firemen who could possibly be killed if the tank burst.

The plan selected was this: Drive the ladder truck and the foam truck down the highway across from tank 91. Two men in the bucket on the arm of the ladder truck would shoot the foam at the rim. Three tanker trucks would ensure a steady supply of water.

When the highway fire finally burned itself out around 2230 and when the power lines finally shut off 2321, they began their coordinated assault. Once in position the firemen started their work, but despite their efforts they couldn't quite get a sufficient bed of foam on the rim to put it out. It seems that the truck was just too far away to hit the far edge of the rim and the wind prevented consistency of the application. "We were losing more foam than we were putting in." Nevertheless, the effort continued until, "all of a sudden the origination point fire started really boiling up. It looked like it was really getting worse." Fearing an imminent eruption, Capt. R called for an immediate evacuation from their vulnerable position. The men retreated to thaw out themselves and the equipment, and to reassess the situation.

As it turned out, the threatening tank never did break open, but in playing it safe, no men were injured.

INCIDENT ACCOUNT #32

Pumping Station III

Following the failure of the initial attempt to put out the rim fire of tank 91, the firefighters spent the rest of the early morning hours thawing out their equipment in order to get it ready for action.

At 0700, all fire department officers and pump operators reassembled. The aim of the meeting was to share information and to provide everyone with "the complete picture". It was felt at this time that the fire had extended as far as it was going to extend and would eventually burn itself out. Aware that their job might take a number of days, attention had to be paid to scheduling the firefighters in a way appropriate to the immediate conditions and needs. Attention had to be paid to the press also. Calls were coming from all over the country. An official representative had to be designated. Insurance agents would soon arrive after the state fire inspectors, who were attempting to determine the cause of the fire even before it was out.

This proved to be a frustrating day in virtually every respect. The three or four meetings that day seem to have been somewhat disorganized - attended by approximately 50 people, some drifting in and out, some trying to eat meals during the discussion. Above all, the fire chiefs had difficulty cooperating with the officials from the Pipeline Company. In Captain R's terms: "I was expecting them to have their own disaster plan. They were expecting us to have a disaster plan." It was the opinion of Captain R that the expertise should be provided by the Pipeline Company. Instead of a disaster plan, the chiefs seemed to be getting inconsistent information from the Pipeline officials. "Our relationship with the Pipeline folks at that point in time was somewhat strained. We didn't understand each other." Therefore, it was not possible to arrive at an adequate situational assessment.

This confusion was compounded by the sheer numbers of people involved at this point: six fire departments, several oil companies, the police department, the State Fire Marshall's office, the Red Cross, officers from a neighboring plant, newspaper men, insurance agents and other self-proclaimed specialists and curiosity seekers. A small "corporation" was being formed to deal with all of the aspects of the fire fighting endeavors; and during this day the fledgling corporation was clearly floundering about without adequate direction, organization, equipment or resources. Yet pressure was on to find a solution.

Finally, in one of the discussions "we came up with the idea of a steel pipe...with a neck on top that we could hook up over the side of this tank to apply foam around this seal." (Unlike many tanks, these had neither pre-installed foam eductor systems nor fire suppression equipment.) These pipes were designed and a couple of machine shops were involved in the manufacturing.

It took around two hours to produce the pipes. Special foam

trucks were used, in order to have the foam mixed with the pressurized water in the correct ratio. The water tankers were then given the order to begin their cycle.

This attempt to put out the rim fire looked like it would be successful initially but the foam did not prove to be effective. It looked "like its cooking off...too much heat there...burning that foam off," reported Captain R.

After the retreat, new foam was ordered from a variety of sources, including a large truck from a nearby AFB. Unfortunately, a problem was posed by the diversity of these foams: 1) they were incompatible, and 2) not all of them could be used together.

Captain R had an opportunity to view the next attempt from a helicopter (with two other officers). But they only saw the foam not working once again. Among the problems: The AFB foam seemed to be breaking down too quickly, and water could not be supplied fast enough to the site.

More conferences were then held. No viable options seemed to result. Finally, the Pipeline Co. decided to contact experts they had on contract from their subsidiary, S. Oil.

The participation of the experts from S. Oil seems to have been flawed from the beginning. They appeared arrogant, insensitive and incompetent, yet the fire chiefs were obliged to cooperate with them since the fire department officers had been begging the Pipeline Co. to bring in experts. The "experts" ignored the chain of command and spoke more with the chief of a neighboring city rather than with the field commander. Said Chief R., "Everybody was turned off (by the men from S. Oil)."

After an abortive effort at tank 91 using a water tower with a foam eductor neck, consultation led to an idea the officers had refused to implement earlier. The men from S. Oil would climb the tank themselves. Warnings expressed by the chiefs only gave the "experts" cause to further boast of their courage. Reciprocal threats broke out prior to the attempt, with the S. Oil men warned that they had better show quick progress, or else, while one of the latter at one point yelled out, "You abandon me (on the tank ladder) and I'll have your ass."

No sooner had the operation begun than it was discovered that the S. Oil truck needed gas. There suddenly seemed to be confusion about where the foam was coming from. The pumper failed to connect to the truck properly so it had to be fed directly into the top cap. They then proceeded into the dikes next to the tank. Two men climbed up the ladder. But "cracks (with) crude coming through" could be seen near the rim. Despite fear that the condition of the tank might worsen, the command was given to start the water truck cycle and they soon began foaming the rim from their position three quarters of the way up the ladder. Thanks to the earlier delays, however, the truck froze up before being used. The firefighters could not get enough foam educted up high enough. It seemed that the pump was malfunctioning. Once the

effort seemed hopeless, they evacuated the area.

Specialists from a southern company, B & C were asked by the Pipeline Co. to come help. Before they arrived the next morning at 4:00 am, the L fire department responded to the request of the Pipeline Co. However, as an urban fire company dependent upon hydrants, they were of no use in the oil tank fire. There were no hydrants in the tank (farm) area, and the pumping capacity of their truck was by far inadequate. City L soon returned home unable to help.

At 4:00 am, two men from B & C arrived and immediately began to make a size up of the situation. It was clear to the fire chiefs that these men knew precisely what to do, from where to requisition resources and equipment, and how to conduct the operation. Rather than appearing haughty, they demonstrated appreciation for how well the local departments had handled the blaze given their limited resources. They were particularly impressed by the fact that no one had been seriously injured. From B & C's involvement in the effort, the chiefs learned a great deal. It reaffirmed how poorly they had been prepared for such disasters and how much needs to be done to get prepared for disasters in the future.

It would still be a matter of days before the fires in the three tanks would be extinguished. The extreme weather posed continual problems. But with the considerable increase in supply of foam, and with the 3,700 foot water relay drawing on a local corporation's 3 million gallon water pond and with the use of new 5 inch hoses, it finally became possible to subdue the blaze.